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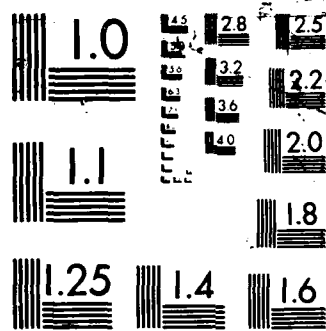
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THE IMPACT OF ONBOARD MAINTENANCE
TRAINING ON SURFACE SHIP READINESS

by

Carl A. Morris

December 1987

Thesis Advisor

David R. Whipple

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The Impact of Onboard Maintenance
Training on Surface Ship Readiness

by

Carl A. Morris
Lieutenant Commander, United States Navy
B.S., The Citadel, 1976

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

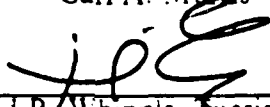
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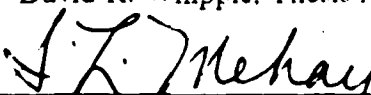
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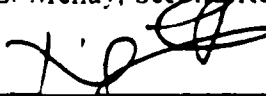
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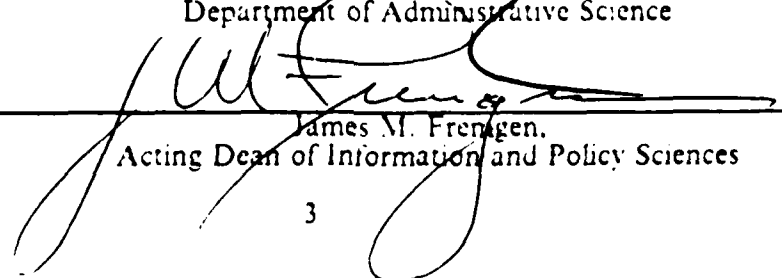

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ABSTRACT

Analysis of shipboard equipment failure rates generated by merging Navy casualty report and Unified Industries Onboard Maintenance Training (OMT) data bases demonstrate a measurable positive effect on reliability in those ships which participated in the program. When comparing equipment failure rates of these trained ships before and up to three years after the training event, over 70 percent of the time there was definite net positive effect. This positive effect was not found to be statistically significant at normally recognized levels ($\alpha \leq .1$), but the effect is readily apparent. Eleven OMT courses, comprising 1176 shipboard training events over six years were examined. Equipment failure rates for trained units are compared before training with those for the three years following training. While the analytical results of this thesis present quantitative evidence of the positive effect of OMT on equipment readiness, this study also discusses the significant economic efficiency of the program as an alternative to contracted equipment repair.

The Unified Industries Onboard Maintenance Training (OMT) program, which was initiated in 1971, is a shipboard training program designed to improve the readiness of shipboard equipment. The program is based on the premise that the most effective way to improve equipment readiness is to train the personnel who are responsible for the equipment. The program is a comprehensive training program that covers all aspects of equipment readiness, including maintenance, repair, and operation. The program is designed to be a continuous process, with training events occurring regularly throughout the year. The program is designed to be a self-sustaining program, with the training events being conducted by the shipboard personnel themselves. The program is designed to be a cost-effective program, with the training events being conducted at a fraction of the cost of contracted equipment repair.

THESIS DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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I. INTRODUCTION

A. BACKGROUND

The Department of Defense (DOD) is a unique internal labor force primarily because it "trains technicians, it does not hire them" [Ref. 1: p. 142]. Annual Department of Defense (DOD) resources programmed for training approached \$29 billion during Fiscal Year (FY) 1986. The Navy alone committed over 17 percent of its available manpower and more than \$5 billion to training in some form during FY 1986 [Ref. 2: p. IX-3 & X-4]. As this country's technological advantage over its principal national security threat narrows and the sheer numerical size disparity continues to widen, the skill of servicemembers effectively employing and maintaining expensive high technology weapons systems will become even more critical. The type and quality of skills provided the military labor force today will have a dramatic impact on force readiness tomorrow and far into the future. Current fiscal realities demand that military managers achieve the largest incremental improvement in national security for each dollar spent. Perceived efficiencies often do not provide sufficient justification to expand or even continue productive programs. DOD and congressional budget decision makers must be given hard facts, sound analysis, and realistic recommendations on which to base calculations needed in arriving at optimal defense program mix.

The ability to relate different training programs to increases in productivity would provide decision makers necessary information on which to base Program, Planning, and Budgeting (PPB) choices. In the training discipline, a majority of the body of knowledge explains the design and execution of programs. Most training research examines individual performance by testing immediately after and at intervals following training. Such research merely measures mental retention of training rather than any incremental change in productivity of the trainee as a member of a labor force or, in the DOD case, a military unit. Tying military training techniques to changes in force readiness is the goal of this thesis.

The Navy's Onboard Maintenance Training (OMT) program is the specific training vehicle through which changes in surface ship material readiness will be studied in this thesis. Ship material readiness will be measured by changes in failure

rates for several classifications of equipment as reported by the Casualty Report (CASREPT) system.

B. OBJECTIVE

The goal of this thesis is to explore differences in shipboard selected equipment readiness using the criterion of crew participation in the Navy Onboard Maintenance Training (OMT) program. Using Unified Industrie's OMT data base and the Center for Naval Analyses' CASREPT data base, the linkage between specialized crew training and equipment failure rates will be analyzed.

In addition to failure rate analysis, the economic efficiency of OMT as both a pseudo-embedded training program and an equipment repair method will be discussed. This discussion centers on a comparison of training costs for OMT and Navy skill progression, C-school training. An example of repair cost savings will compare successful contract bids for equipment repair found in the Commerce and Business Daily (CBD) with total costs of OMT repairs of identical equipment.

C. SCOPE AND ASSUMPTIONS

1. Scope

The focus of this research is to examine the direct impact Onboard Maintenance Training has had upon fleet equipment readiness as measured by failure rates generated from CASREPT data. This study does not attempt to construct a sophisticated model designed to explain the multitude of inputs and their relative importance in producing ship readiness. Further, this thesis will not conduct an extensive cost benefit analysis of the OMT program. Rather, by applying the concepts of previous training cost studies and discussing an example of the cost of a contracted equipment repair and comparing the cost with that of the OMT alternative, conclusions relative to the budgetary efficiency of the program will be drawn.

2. Assumptions

The primary assumption in this research is all other inputs to ship readiness are held constant across class. The study methodology dissects readiness by 11 categories of equipment found on 21 types of surface ships (See Table 1 and 2). Any concerns over this primary assumption are minimized by the large sample size. Almost five years of maintenance data from October 1982 to March 1987 are examined. Classwide statistics are generated from over 90,000 CASREPTs during the study period.

TABLE 1
CATEGORIES OF EQUIPMENT STUDIED

Air Conditioning and Refrigeration
Air Compressor
Centrifugal Pump
Degaussing
Dehydrator
Electric Motor
Firefighting
Mk 19 Gyro Compass
Steam Valve and Regulator
60/400 HZ Converter
60/400 HZ Motor Generator

TABLE 2
TYPES OF SURFACE SHIPS STUDIED

<i>SHIP TYPE</i>	<i>DESIGNATION</i>
AD	Destroyer Tender
AE	Ammunition Supply
AO	Oiler
AOE	Oiler and Refrigerated Stores
AR	Tender
CG	Guided Missile Cruiser
CGN	Guided Missile Cruiser Nuclear
DD	Destroyer
DD-963	Spruance Class Destroyer
DDG	Guided Missile Destroyer
DDG-993	Kidd Class Guided Missile Destroyer
FF	Frigate
FF-1052	Knox Class Frigate
FFG	Guided Missile Frigate
FFG-7	Perry Class Guided Missile Frigate
LCC	Amphibious Command
LHA	Amphibious Helicopter Carrier
LPD	Landing Platform Dock
LPH	Landing Platform Helicopter
LSD	Landing Ship Dock
LST	Landing Ship Tank

Another major assumption is that CASREPT data accurately and objectively reflect ship maintenance performance. Opinions have been voiced [Ref. 3: p.16] that CASREPT data are not an entirely appropriate performance measure. The most serious shortcoming of this reporting system is that, while the criteria for filing CASREPTs is well documented (an equipment failure affecting a ship's primary

mission area not correctable within 48 hours), many commands practice "gamesmanship" in adhering to these guidelines. This individual command effect is minimized by the fact that classwide statistics are generated over a long time period. Other assumptions includes that:

- The results of other studies used are reliable.
- The data provided by Unified Industries C.N.A. and other Navy sources are reliable.

D. SUMMARY OF FINDINGS

Analysis of failure rates generated by merging the CASREPT and Unified Industries OMT training data bases found a measurable positive effect on equipment reliability in those ships which participated in the program. When comparing equipment failure rates of these trained ships before and up to three years after the training event, over 70 percent of the time there was a definite net positive effect. This positive effect was not found to be statistically significant at normally recognized levels ($\alpha \leq .1$), but the effect is readily apparent.

Table 3 presents results of this study for the eleven OMT courses examined. Equipment failure rates for trained units are compared before training (λ_1) with those for the three years following training (λ_2). Those courses displaying positive effects ($\lambda_1 - \lambda_2 > 0$) comprise 70 percent of the OMT training events studied.

While the analytical results of this thesis present quantitative evidence of the positive effect of OMT on equipment readiness, there is also a significant economic efficiency of the program as an alternative to contracted equipment repair. One cost comparison provided by Unified Industries presented the cost of a class C overhaul on an Ingersoll Rand low pressure air compressor. The contracted price for this repair advertised in the C.B.D (Commerce Business Daily) fluctuated between \$85,000 and \$115,000. The OMT repair expenses included the manufacturer's overhaul kit \$29,000, the cost of the instructor for three weeks \$3,000, and a portion of the military pay and benefits for the five sailors involved during the training period. Allowing this opportunity cost of the crewmembers to vary considerably the identical OMT repair is easily half the cost of the contracted work. The economic efficiencies of shipboard training are addressed later in this study.

TABLE 3
FAILURE RATES BY COURSE (TRAINED UNITS, 3 YEAR TIME
HORIZON)

<i>COURSE</i>	$\lambda_1 - \lambda_2$	<i>PVALUE</i>
AC&R	.000084	.99
AIR COMP	.000519	.99
CENTPUMP	.000034	.94
DE	-.000081	.34
DRY AIR	-.000155	.40
ELEC MOT	.000018	.70
FIRE	.000379	.99
MK 19	.000207	.83
STEAMVAL	-.000101	.12
60/400HZ	.000971	.97
60/400MG	-.000278	.48
λ_1 - Failure Rate w/o OMT		
λ_2 - Failure Rate /w OMT		

E. ORGANIZATION OF STUDY

Chapter II provides background for this study by explaining the general structure of Navy training. A brief history of the Onboard Maintenance Training Program and it's contribution to fleet self-sufficiency is also presented.

Previous research which applies to this thesis is discussed in the Chapter III literature review. Studies in training, and military readiness, concentrating on productivity, efficiency, and budget cost comprise the bulk of this chapter.

In Chapter IV, the methodology used in creating the data bases and the alternative experimental designs are discussed. An explanation of the appendices dealing with FORTRAN programs is also provided. Remarks on the statistical analysis of the data, results of the study, and the SPSSX and SAS programs used is dealt with in Chapter V.

Concluding remarks and policy recommendations are made in light of the results in the final chapter. Chapter VI also provides ideas for further studies using the Unified Industries and CASREPT data bases.

II. BACKGROUND

A. NAVY TRAINING OVERVIEW

To understand how Onboard Maintenance Training affects shipboard material readiness, an explanation of the general structure of Navy training is needed. Specifically, since it is the enlisted ratings which conduct equipment maintenance aboard ship, it is their training that will be the primary focus.

Navy enlisted occupational standards identify the tasks of each Navy rating by paygrade within each rating. Tasks within the occupational standards fall generally into categories of operation, maintenance, or management. These standards are intended to form the basis upon which enlisted personnel are trained, assigned to duty, and demonstrate qualifications for advancement in rate. Specialized tasks requiring training, but not included in the occupational standards because only a small percentage of the rate need carry them out, are grouped into Navy Enlisted Classification (NEC) codes. Enlisted billets in each command are identified in the Ship Manning Document (SMD) by rating, rate, and, if applicable, one or more NEC codes.

1. Shore Based Training

The Navy Enlisted Personnel Distribution System, in conjunction with the Navy Training System, seeks to match skills required by "spaces" with the skills of "faces" available for assignment. Enroute training provides the opportunity to correct skill deficiencies which may exist between the billet requirement and the personnel assigned. The training system available for this purpose is comprised primarily of shore-based resident military schools, to which individuals are assigned as a duty station, to develop the skills required of their next assignment.

Another portion of the shore-based school system is the installation support school, usually located in areas of fleet concentration at Fleet Training Centers (FTC). Installation support schools are organized to meet local training needs, although they conduct a large number of courses which are duplicated at other schools. Students are normally sent from their commands on a temporary duty under instruction basis, for return to the parent command after training.

Remaining training that is conducted is accomplished within each command and is referred to as onboard training. When the command is a ship, this training is

called shipboard training. The conduct of shipboard training is the responsibility of the ship's Commanding Officer, with oversight responsibility flowing up through the Fleet chain of command.

2. Shipboard Training

The principal objective of shipboard training is to prepare a crew to perform effectively as members of the many teams needed to operate and fight a ship. The development of individual skills to support performance as a team member is dependent upon the rating involved. The amount of rate training provided in shore schools prior to reporting aboard ship varies significantly across ratings. Initial specialized training for some ratings emphasizes operational training, to facilitate qualification as an underway watchstander as soon after reporting aboard as possible. For a number of ratings, there is practically no formal training provided prior to the member's reporting aboard. Thus the shipboard skill environment requires a training program tailored to meet specific needs of each group of ratings.

Operator watchstanding training normally receives the majority of formal shipboard training time and resources. Watchstander training is managed through the theory, systems, and watch sections of the Personnel Qualification Standards (PQS) program. Except in commands with self-designed formal maintenance training, there is generally no such program available.

There is a general understanding within the Fleet that maintenance training is important, but the limited resources of time and skills, and the priority placed on operator training has resulted in maintenance training being diminished. Thus, the lack of a fleetwide formal maintenance training program aboard ship is due more to the lack of any effective delivery system and training resource material than it is to a perception of lesser need.

It was in this almost nonexistent maintenance training environment that the Navy of the late 1970s found itself. To compound this situation, 1976 through 1980 was one of the bleakest periods of careerist retention for the Navy in recent history. With experienced and skilled senior enlisted manpower at an ebb, Fleet commanders began observing a degradation in ship material readiness [Ref. 4]. With no near-term prospects of improvement, emergency intensive care was needed to restore shipboard maintenance to self-sufficiency.

B. CONTRACTED MAINTENANCE TRAINING

1. Shop Qualification Improvement Program (SQIP)

Commander Naval Sea Systems Command (NAVSEA) as the technical hardfare manager for the Navy, in 1976, recognized the existence of a shortage in skilled personnel at fleet Intermediate Maintenance Activities (IMA). Productivity of these important sailor-manned repair organizations, both tenders and ashore, was declining. In 1977 NAVSEA code 041 initialized the Shop Qualification Improvement Program (SQIP). Through this program, contracted civilian¹ instructors provided industrial repair skill and management training to all surface and submarine IMAs including industrial level shops on aircraft carriers (CVs). NAVSEA envisioned this program as a fix in three important areas. First, repair skill training would improve the capabilities of IMAs and facilitate their execution of NAVSEAs equipment and ship class maintenance strategies. Second, by requiring highly qualified, experienced instructors, the Systems Command now had the ability to provide technical improvements and guidance face to face in addition to routine documentation. Third, and perhaps most unexpected, instructor post training reports enabled NAVSEA to receive personal feedback from the fleet on which the technical community could react.

In 1977 NAVSEA contracted courses in 17 IMA industrial repair skill areas. Planning Research Company (PRC) conducted courses in 12 of the skill areas and Unified Industries Incorporated (UII) provided the remaining 5. The SQIP program today conducts 23 skill area courses as well as the management, documentation, and advanced technical support delineated in the program's 1977 charter.² Fiscal Year 1986 funding for SQIP was \$4.32 million. [Ref. 5]

2. Onboard Maintenance Training (OMT)

Both surface type commanders recognized the inherent rationale of "hands on" maintenance training and saw the positive effect the infant SQIP was having on IMA productivity. Late in 1977, Commander Surface Force Atlantic Fleet petitioned the chain of command to provide onboard SQIP type training as a pilot program on 600 and 1200 psi propulsion ships. The Chief of Naval Operations approved a pilot program in June 1978 with the objective of evaluating the concept for possible

¹Civilian is not an accurate description for these instructors. All were retired Navy Chief Petty Officers in repair ratings with at least six years of IMA experience, and Navy instructor training.

²This information was provided via phone conversations with Mr. Bob D'orsy Unified Industries, San Diego, California.

expansion and inclusion in the 1981 POM (Program Operation Memorandum).

A pilot centrifugal pump repair course was conducted in 1979 on both coasts by PRC. The results of the pilot program were predictable. Shipboard pump maintenance teams trained during the program immediately started to work overhauling other pumps and training fellow crew members in repairs which would have been otherwise deferred for off ship accomplishment.

The unqualified success of the pilot program in the fleet resulted in its expansion to 23 equipment courses. Funding for OMT in fiscal year 1986 was only \$850,000. To understand why SQIP blossomed while OMT, with perhaps an even greater potential, did not, one must delve into Navy politics.

Almost from the inception of the two training programs, their sponsor, NAVSEA, sought to transfer their cognizance from the material command to the training command. NAVSEA's position was articulated as follows in a 1981 point paper:

In accordance with NAVMATINST 5460.2A, the personnel and training support functions of the Naval Sea Systems Command are limited to advising officials of the Department of the Navy, as appropriate, on training and technical requirements for the operation and maintenance, by Naval personnel, of equipment under development, and for providing equipment, technical data, support, and documentation for the operation and maintenance of material for which NAVSEA has support responsibilities. The OMT program has evolved to include administration of major field training operations.

With OMT now well established, it should be organizationally realigned to become part of the Navy Training System with respect to program policy, objectives, funding, and management control. Such placement will permit its operation and growth to be coordinated with existing and other new initiatives in onboard training assistance being developed, such as the Shipboard Propulsion Plant Operator Training (SPPOT) project. However, it is acknowledged that there is not currently a centralized organizational structure in the Navy to manage onboard training assistance projects. Using the OMT program as a catalyst and pilot program, the development of such a capability within the Navy could proceed expeditiously.³

Chief of Naval Education and Training (CNET) did not wish to further broaden his area of responsibility by assuming control of the OMT program. CNET position was presented as follows:

³This material is from an organizational plan outline to shift management responsibility for Onboard Maintenance Training (OMT) from NAVSEA to OPNAV, dated 22 October 1981.

Formal training cannot continue to be increased indefinitely to meet intensifying demands for additional training, because of time, funding, and instructor personnel constraints. The difference in training requirements and formal training available will be filled by onboard training (OBT). The OBT available is currently at a multitude of levels from shipboard generated, to Systems Commands and OPNAV sponsored, and contractor prepared. Frequently OBT is not coordinated between the many sponsoring activities resulting in duplication of effort, extensive resource requirements, and confusions in the fleet and shore stations as to OBT program procurement and implementation. Central to this theme is the requirement for the designation of an organization to centrally manage the OBT program within the Navy.⁴

CNET recommended that a branch within OPNAV be created to manage onboard training. This debate concerning onboard training continues to this day. Under the sponsorship of OPNAV (OP-43), NAVSEA's contracting support and technical oversight, and Type Commander (TYCOM) day-to-day direction and scheduling, OBT as continued at relatively low funding levels. Funding levels were so low that support of courses in two homeports were cancelled in 1985.

C. FUTURE OF HIGH-TECH SKILLS

With the advent of ever more complex propulsion, weapons, and support systems on fleet units, both new construction and backfitted, the modern Navy is demanding a greater number of specialized skills in shipboard crews. Training pipelines can stretch several months between duty stations attempting to match billet needs with personnel skills. The further expansion of shore-based training with its inherent loss of service member productivity is not an appropriate answer to the problem.

The current solution, reliance on civilian technical representatives (TECHREP) to repair shipboard systems procured from their corporations, is also not appropriate. In 1985 the Chief of Naval Operations (CNO) directed⁵ the reduction of Navy dependence on afloat civilian TECHREPs [Ref. 6: p. 126]. His July 1987 TECHREP elimination date has passed uneventfully and afloat civilian skilled workers remain a reality for the Navy. The Navy appears to accept this overall civilianization trend when it announced in 1986:

⁴This material is quoted from a Chief of Naval Education and Training letter to OPNAV dated 1 April 1981, signed by his deputy at the time, J.M. Poindexter.

⁵Memorandum, Adm. James D. Watkins to the deputy chiefs of naval operations for submarine warfare, surface warfare, and air warfare. "Civilian Engineering Technical Service (CETS) Personnel," 5 April 1985.

Continuing efforts are underway within Navy to reduce the overall level of military manpower requirements through civilianization.⁶

The Navy goes on to rationalize this labor substitution trend by noting the significant savings of trained military manpower this program has allowed.

The efficiency in civilian labor over military, in some missions, should not be lost on manpower planners. Civil service assumption of military billets or TECHREP repair of complex shipboard equipment, including aircraft, is not the best form of civilianization, although they have become quite popular. Rather, private contracting of support and training manpower appears to present concrete avenues for savings. The skilled military trained technicians that left the service causing experience shortfalls can now be contracted to provide the very same services, but as civilians. Lower overhead and a willingness to work in the familiar military environment at possibly below market wage (excluding the sunk cost of retirement pay) would enable the Navy to capture a cost savings. The economic efficiency of competitive contracting is in the early stages throughout DOD. Using low-cost labor to liberate military manpower for more critical purposes can lower the price and improve program efficiency, particularly in manpower-intensive missions such as training.

Shipboard maintenance managers are finding an ever increasing gap between equipment installed and personnel with necessary skills to effect onboard repair to that equipment. A case in point is the auxiliary propulsion equipment on Spruance class destroyers (DD-963). The rating assigned repair responsibility over firepumps, air compressors, and the LM2500 gas turbine engine is the same, Gas Turbine Mechanic (GSM). While GSM A and C school training⁷ prepares these students for many turbine-related malfunctions, personnel in this rating receive almost no background in basic repair of the peripheral propulsion equipment. Designed redundancy in auxiliaries has attempted to replace the need for self-sustainability in these vessels.

This trend toward reliance on outside maintenance of shipboard equipment manifests itself in the minimally-manned Oliver Hazard Perry Class (FFG-7). Designed equipment failure rates, requisite equipment duplication, and regularly scheduled

⁶Office of the Assistant Secretary of Defense (Manpower, Installation and Logistics). *Military Manpower Training Report for FY 1986 Vol III and IV*. Washington, D.C.: Department of Defense, 1985. pp.IV-38.

⁷Class A school training is basic skill instruction normally provided following recruit training. C school training is designed as a first term reenlistment incentive for sailors with fleet experience.

Industrial Maintenance Availabilities (IMAV), which conduct class maintenance plan replacement of installed auxiliaries, is a way of life on these ships. Variances in equipment failure rates, supply availability of reworked carcasses, and ship employment detract from the success of this repair philosophy. Fleet Engineering Officers on these classes of ships have found OMT to have great impact on their self-sufficiency.

Senior Navy officials, both NAVSEA and Fleet Commanders, recognized the need for a program to improve shipboard equipment maintenance self-sufficiency in 1978. The SQIP and OMT programs were developed and evaluated as successfully meeting these hands-on maintenance training goals. Unfortunately, while the NAVSEA-tasked IMA-centered SQIP has flourished, the equally effective shipboard program has been stagnated by unclear sponsorship and training area responsibility. The crucial question is, had the OMT program received full support and appropriate funding over the past seven years what would the Navy's mission readiness be? To more fully comprehend the possible impact OMT could have on the fleet, an understanding of productivity and training and military readiness is required. The next chapter will review literature associated with these areas.

III. LITERATURE REVIEW

The body of knowledge as it applies to this thesis exists in three general disciplines: productivity, training, and military readiness. The interaction of researchers in these areas has produced several works on both training efficiency and military readiness productivity. The assimilation of this literature as well as graduate studies provided a sound theoretical foundation on which to frame this study.

A. MILITARY READINESS PRODUCTIVITY

An excellent summary of literature concerning military productivity research is provided by Horowitz [Ref. 3: p. 13-28]. In this paper, he also develops a causal chain that links Manpower, Personnel, and Training (MPT) policy decisions to increased readiness. He explains the feasibility of transforming this chain into a set of quantitative planning instruments. One of the most important discussions in Horowitz's evaluation concerns directing MPT analysts toward the use of available quantifiable data rather than the use of subjective survey data. The merging of these already available partial indicators of performance into a substantially improved indication of military output will provide a measure upon which MPT policies can be formed and expenditures justified. The use of CASREPT data in this thesis is one of the quantifiable data types mentioned by Horowitz. The OMT data base is again an example of the untapped data MPT researchers could use to study training programs. The combination of these data bases in the two forms provided in this thesis can be used in tangent studies of training methods and equipment reliability.

Warner [Ref. 7], in an earlier paper with much the same theme, summarizes the then current knowledge of Navy manpower problems and focuses on possible directions for future studies. Warner develops a theoretical framework for evaluating manpower issues in terms of supply and demand. He stresses the issue of quantifying military demand with efficient measurements. Readiness, the output of military labor, is examined in this thesis. If training programs such as OMT can improve the productivity of military labor it follows that demand can be reduced. This thesis proceeds from Warner's recommendation for research in both readiness and training disciplines.

Hogan [Ref. 8] discusses a broad range of efficiency and productivity topics, as they apply to Defense manpower issues. He examines and critiques DOD techniques designed to promote efficiency in manpower determination, hardware experience mix tradeoffs, and the efficiency impact on the All-Volunteer-Force. This article provided a general knowledge of the budgetary decision process within DOD. Programs such as OMT which contribute to efficiency in two areas, maintenance and training, should receive high budgeting priority.

An early study which used CASREPT data as a criterion measure of surface ship productivity was conducted by Horowitz and Sherman in 1977 [Ref. 9]. They examined the performance of maintenance ratings on surface ships. Aggregate ship statistics were developed from the enlisted master file of every crewmember on 91 ships studied. These data were then weighted by the individual's length of duty on the ship during the study period. The enlisted characteristics, examined by occupation include crew size, Armed Forces Qualification Test (AFQT) scores, education, past sea experience, rank, length of service, marital status, race, and training courses attended. One of the effects they observed was that variations in productivity reflected variations in training in all ratings except Firecontrol Technicians (FT). These findings predict an observable effect on ship readiness caused by a maintenance training program such as OMT. Including other than formal training as a variable captured in the data bases produced in this thesis, may explain even more fully variances in ship readiness.

Horowitz [Ref. 10] condensed several previous studies concerning Navy enlisted productivity conducted while he was at the Center for Naval Analyses. In this monograph, Horowitz suggests how these studies might apply to Army manpower issues. Knowledge of previous studies and research methods prevents analysts continually reinventing the wheel. This review serves this important purpose, as well as demonstrating the similarity of manpower issues among military services.

A 1984 study conducted at the U.S. Military Academy [Ref. 11] examined the impact of mental groups and high technology on tank crew performance. This research suggested that advanced technology weapons systems need not require the high quality operators the Services claim. The theme of this study is that technology may make systems increasingly easier to operate, but the same is not necessarily true for maintenance tasks on these more complex systems. The impact of advancing technology on the Navy has not gone unnoticed. The requirement to compete in the electronic environments above, below, and on the high seas has created a reliance on

high-tech weapons, communication, and propulsion systems. These systems maybe user friendly, but tend to require ever increasing experience levels in maintenance personnel.

Howell [Ref. 12] models the effect the experience levels of maintenance crews have on the Air Force F-4E sortie generation. His research concluded that more experienced, skill-level 5 maintenancemen were over 25 percent more productive than the lower experienced skill-level 3 personnel. This contention that productivity is a function of time-on-the-job opens the prospect for improvement in the skill-generating activities of on-the-job training. Programs such as OMT may, in fact, shorten the time required to transition to a more productive skill level.

The damaging effects increased personnel turbulence has on civilian productivity have been well documented. The effect of turbulence on military units has more recently been studied by Tragemann [Ref. 13]. He discovered significant improvements in unit readiness by stabilizing individuals within deploying units using the Army Cohesion Operational Readiness and Training System (COHORT). Entire unit reassignment is not new to the Services. The Navy Fleet Ballistic Missile Force established blue and gold crew rotation from its inception. This personnel policy sought to increase production of strategic deterrence by more efficient use of existing capital investments, SSBNs. This turbulence effect is not lost on the the surface Navy. The gapping of critically skilled billets while awaiting in-route shore training of reliefs can adversely affect unit readiness. If a policy of reducing shore school duration by transferring a portion of the training to more productive on-the-job training were in place, personnel would spend greater amounts of time actually onboard each ultimate duty station.⁸ OMT provides an efficient program to expand crew experience levels in specialized maintenance skills without prolonging existing off-ship training pipelines.

B. TRAINING EFFECTIVENESS

As the Navy seeks to improve force productivity, research into more efficient training methods may produce as large a gain as advancing technology. To be fair, high technology applications in the training field are themselves opening new vistas requiring cost-benefit analyses. Research by Balis [Ref. 14] was mainly concerned with estimating skill and experience mix and the level of reenlistment bonus necessary to maintain an efficient force structure. Of interest to this study is his mechanism for

⁸An ultimate duty station is the final reporting activity on an individual's transfer orders. In the case of a servicemember being transferred to a ship via shore schools, this process may span more than a year.

estimating initial training costs of recruits. If programs can be developed which provide the necessary skills to these new sailors more economically than the existing shore-based training system, skill thresholds or the number of students trained could be increased.

Marcus and Questor [Ref. 15] investigate occupation-specific learning curves of first-term Navy enlisted personnel, using the Rand Corporation's Enlisted Utilization Survey (EUS). The purpose is to estimate the Navy's sunk-cost payback horizon for varied length service schools. The study estimates the minimum length of obligated service required for the Navy to recoup this investment in human capital. These training cost estimates for specialized training are of interest to this thesis.

Two related studies by Questor [Ref. 16] and Downey [Ref. 17] seek to explain to the Chief of Naval Operations (CNO) why quality of life improvements of the early 1980s improved retention but did not realize the anticipated savings in reduced training costs. These studies reveal that Navy enlisted endstrength proportions have moved toward more careerists, and these career designated sailors, by definition, require higher levels of specialized skill training. Additionally, specialized skill training at the C-school level has expanded significantly.

These two studies document the fact that C schools are the most manpower-intensive Navy skill training. While the Training command has embarked on an expansion in these military labor intensive schools, the cost of that labor has risen dramatically. One conclusion that can be drawn from these studies is that continued reliance upon shore-based, military manpower-intensive skill training is not the most efficient use of scarce training dollars or military manning. The OMT program is a direct competitor for the specialized skill training dollars spent to support some maintenance related C schools. It is crucial that the military sharpen its ability to recognize and implement training programs which are more effective or economic than those currently in place.

Malehorn [Ref. 18] provides an excellent theoretical framework to explore the cost-benefit relationship of embedded training.⁹ He develops a series of Strawman statements which represent possible efficiencies of the embedded training method.

⁹Embedded training is training that is provided by capabilities built into or added onto operational systems, subsystems, or equipment to maintain and or enhance the skill proficiency of fleet personnel. Further, an embedded training device is designed and manufactured as an integral part of an operational system's hardware software or consists of separately developed external hardware software which interfaces with an operational system.

Programs such as OMT, which use existing equipment to conduct skill training, in the broad sense, qualify as embedded training. This Strawman technique of exploring the cost-benefit relationship of OMT contrasted to the more traditional methods of imparting specialized skills is one way of conducting a cost evaluation of different training programs. Many of Malehorn's possible embedded training payoffs are realized by OMT. These applicable payoffs include:

- All travel, billeting, subsistence, and administrative costs associated with moving students to the instruction site are avoided.
- Costs associated with maintaining formal schools i.e., capital investments, personnel costs of instructors and staff, and base support expenses are foregone.
- Students opportunity costs are lower than in formal schools as they remain available for partial shipboard military duty.
- Training is conducted on specific shipboard equipment with immediate student applicability. Learning is quickly reenforced with greater mental retention.
- OMT training overhauls shipboard equipment which would otherwise require off ship repair facilities to conduct the repair.

This literature review would be incomplete without mention of work conducted by Reslock and Gregory [Ref. 19] in preparing the Center for Naval Analyses CASREPT data base. This explanation of the CASREPT data base was clear, concise, and error-free. Ms. Reslock was the point of contact at the Center for Naval Analyses for the CASREPT data base used in this thesis. Her rapid response to requests for data and sound explanations were instrumental to this work.

The literature reviewed for this thesis has charted the course for the use of quantitative measures of military productivity, the CASREPT data base, to study a specialized maintenance skill training program, which utilizes the economic efficiency of a shipboard embedded training environment.

IV. METHODOLOGY

A. DATA MANIPULATION

The two files used to conduct this investigation are the Center for Naval Analyses CASREPT data base from October 1982 to March 1987, and the Unified Industries Training Data base from January 1981 to July 1987. The CASREPT file consists of over 149,000 data points and the Unified file of over 26,000 data points. Record layout for the CASREPT data base is provided in CNA report 86-28 [Ref. 19: Appendix B]. Layout for the entire Unified Industries data base is provided in Appendix A of this thesis.

Before any data manipulation could take place the data bases contained on magnetic tape were loaded on to the Naval Postgraduate School computer center mass storage system. Programs 1 and 2 in Appendix B upload the UNIFIED Industries and CASREPT data respectively.

1. Uploading Tapes and Data Reduction

The first step in using these two files was to conduct descriptive statistics on the variables contained within them. Of particular interest were the two OMT sections of the Unified data set. This data set contained individual crewmember training data and ship data as separate subfiles. As this study explores the total effect of OMT on ship readiness, only the ship files were considered. There are over 1,300 training events during the period studied in this subfile.

Ship class selections were made to reduce the total number of calculations while maintaining adequate sample size. The ship class selections shown in Table 2 represent 94.4 percent of the OMT ship training file. Identical rationale was relied upon in making equipment course selections from the OMT file. Those skill areas shown in Table 1 comprise 93.1 percent of the total training file. These selections allowed 87.1 percent or 1,176 OMT training events to be analyzed during this study. These frequencies can be found in Appendix B section 3.

The next step was to match the OMT training courses with equipment identification codes (EIC).¹⁰ EIC's are one of the data fields provided in each

¹⁰An equipment identification code is a four character code used to exactly identify specific Navy equipments. These codes are contained in the Navy's *Equipment Identification Code Manual* [Ref. 20].

CASREPT record. The eleven OMT courses correspond to 110 EICs. The relationship between courses and EICs is contained in the FORTRAN program found in Appendix E. By relating each OMT equipment course to the corresponding EIC's on which the training is applicable, the CASREPT records for those EICs are examined. Program 3 Appendix B creates the subset of the OMT file for Table 2 ships training records. Program 4 Appendix B separates only those CASREPTs from ships in Table 2 and EICs corresponding to training courses in Table 1.

2. Creating a Dummy OMT Training Variable

Before both the OMT and CASREPT files can be operated on together, data fields containing ship hull number and all dates must be in identical formats. Ship hull numbers in the Unified files were changed to match the CASREPT form. Thus, AOR-5 becomes AOR 0005. Training dates on the OMT data base were in a six-digit year, month, day form. Because failure rates were to be computed in failures per equipment days these training dates were converted to the pseudo-Julian date configuration found in the CASREPT file. This sequential date counter begins with day 00001 on 1 January 1974. These operations are accomplished on the subset.Unified file by program 5 found in Appendix C. Program 6 in the same Appendix is an SPSSX procedure used to sort this file (subset.Unified1) by ship hull number, course title, and training date creating subset.Unified2 on the mass storage system. This second sorted subset of the OMT data base was used as input to the failure rate calculation program in Appendix E.

Now the CASREPT and associated ship OMT files can be read and related to each other in a single program. The FORTRAN program in Appendix D reads each ship's training data, hull number, course name, and course date, contained in the subset.Unified1 file and then searches the CASREPT file for reported failures in each EIC covered by that particular course. The mass storage file created by this program contains ship identification data, total down time for the CASREPT, the breakdown of down time by supply and maintenance, the EIC involved, and a field relating to OMT in the form of a 0,1 entry. The dummy OMT variable will be 0 if OMT had not been conducted on the CASREPT EIC within three years.¹¹ A 1 is found in this field if training had been provided by OMT within the three year time frame.

¹¹A three year training effect period was chosen in light of current expected sea tour lengths of the maintenance ratings targeted by the OMT program. One and two year training effect horizons were also examined and will be discussed in Chapter V.

This CASREPT OMT data base allows investigation of differences in the variables contained in the CASREPT file. Variations in the amount of equipment down time and the portion of the down time that is supply or maintenance related could be examined. This study was centered on the comparison of equipment failure rates and this combined CASREPT OMT dummy file measured only equipment down time. A file which captured failures and equipment life was needed.

3. Generating Failure Rates

Because the OMT dummy file depended upon the report of casualties to equipment to derive an indication of changing reliability, the generation of a more appropriate failure rate file was required. The Appendix E FORTRAN program creates this file. The failure rate procedure divides the CASREPT file into control and treatment groups with OMT training conducted within three years of the CASREPT being the treatment. To calculate failure rates, casualties must be counted and then divided by a total time variable.

Equipment time is computed from each ship's initial beginning CASREPT date to the end of the CASREPT file (31 March 1987) for each of the 110 EICs. All ships begin in the control group and some migrate into the treatment group when onboard training occurs. Ships may also move back into the control group when the 1095 day (three year) training effect clock runs out. Failures are counted by ship and EIC depending on whether the CASREPT happened during a training or non-training period.

Now that time in equipment days and failures have been found the program sums each ship's EIC control and treatment data by class of ship. The resulting file contains ship class, failures and time during non-trained periods, non-trained failure rate, failures and time during trained periods, trained failure rate, EIC, and the associated OMT course title.

The file described above was then filtered by removing all EICs for which there were no failures in the control and treatment groups. This reflected the fact that some classes of ships do not have all 110 equipments installed or that the equipment simply did not fail as reported by the CASREPT system. In either case this data was of no use to the study.

Identical summed failure rate data bases were created using one and two year training effect time values. A FORTRAN program creating an alternate experimental design is also included in Appendix E. This methodology examines only ships which

participated in OMT.¹² These ships equipment failure rates prior to the training event comprise the control group, failure rates following specific courses produce the treatment rates. Again, three data bases were created using the three, two, and one year training effect horizon. The summed failure rate data bases were small enough to reside on the authors A disk allowing easy access for statistical analysis. These six failure rate files were compared statistically during the analysis phase of this study.

This analysis will be presented in the following chapter.

B. OVERVIEW

This chapter has explained the raw data used, the transformation of that raw data into a usable form and the creation of four new data sets on which statistical analysis can be conducted. In the next chapter the statistical procedures applied to the three summed failure rate files, and results are discussed.

¹²This methodology was recommended by Dr. Loren M. Solnick, Department of Administrative Sciences, Naval Postgraduate School.

V. DATA ANALYSIS AND RESULTS

A. DATA ANALYSIS

1. Computing Aggregated Failure Rates and F-Statistic

The data bases produced by the two Appendix E FORTRAN programs and the one and two year training experience horizon variants of them, provide failure data by class of ship, EIC, and OMT course title. These data are already the aggregation of data from ships within the class. An SPSSx program was used to further aggregate failure and equipment time data. Summed failures and equipment time were used to compute trained and non-trained failure rates which were in turn compared by computing F-statistics and degrees of freedom. By altering the BREAK line of the Appendix F section A program using class, EIC, or course this analysis is conducted on all combinations required.

2. Test for Statistical Significance

Failure rates follow the exponential distribution and as such the generalized likelihood ratio test is from the F-distribution. When the failure rate of equipment with no OMT (control) is λ_1 , and failure rates of equipment having OMT (treatment) is λ_2 , the test the hypothesis $H_0 : \lambda_1 = \lambda_2$ is provided by Equation 5.1.

$$F_{\alpha; 2, n_1, n_2} \leq \frac{2(\sum T_1)2(1 + g_2)}{2(\sum T_2)2(1 + g_1)} \quad (\text{eqn 5.1})$$

Where T_1 and T_2 represent equipment time and g_1 and g_2 are the number of observations, in this case the number of casualties in each sub group (control or treatment) [Ref. 21: p 456]. These values F , n_1 , and n_2 are computed by the SPSSx program mentioned above from T_1 , T_2 , g_1 , and g_2 .

It was necessary to use SAS to calculate observed level of significance or p values, as SPSSx has no direct method to accomplish this procedure. An example of the SAS program using the SPSSx output is presented in section B of Appendix F. The p values produced by SAS are combined with the associated failure rate difference, $\lambda_1 - \lambda_2$ in the tables presented in the next chapter. Together the differences and p values depict the change in equipment failure rates between the control and treatment groups

and the statistical significance of the change. Negative values for this difference reflect lower equipment failure rates in the control group than in the treatment group.

B. RESULTS

Logic and previous research suggests that OMT should reduce equipment failure rates on participant units. Those ships having crewmembers with the ability to correctly operate, diagnose and repair equipments onboard should realize increased equipment reliability. This study found that there was in fact a net positive effect associated with ships that had received OMT training. While this positive effect was not statistically significant at normally accepted levels, the data demonstrate improved equipment failure rates in a clear majority of ships (70 percent) on which training had taken place. Oddly enough, the positive effect of maintenance training on failure rates was found to intensify with time. This time horizon effect holds true for both experimental designs, all units in the control group and trained units only in control groups.

TABLE 3
FAILURE RATES BY COURSE (TRAINED UNITS, 3 YEAR TIME HORIZON)

COURSE	$\lambda_1 - \lambda_2$	PVALUE
AC&R	.000084	.99
AIR COMP	.000519	.99
CENTPUMP	.000034	.94
DE	-.000081	.34
DRY AIR	-.000155	.40
ELEC MOT	.000018	.70
FIRE	.000379	.99
MK 19	.000207	.83
STEAMVAL	-.000101	.12
60/400HZ	.000971	.97
60/400MG	-.000278	.48
λ_1 - Failure Rate w/o OMT		
λ_2 - Failure Rate /w OMT		

This study's results are presented in Table 3 through Table 6 in this chapter and in Table 7 through Table 12 in Appendix G. The results are arranged by first examining OMT's effect with only trained ships in the control group, then with all ships in the control group.

TABLE 4
FAILURE RATES BY CLASS (TRAINED UNITS, 3 YEAR TIME
HORIZON)

CLASS	$\lambda_1 - \lambda_2$	PVALUE
AD	.000462	.86
AE	.000484	.99
AO	.000564	.92
AOR	.000006	.54
AR	-.000520	.08
CG	.000196	.97
CGN	.000843	.98
DD	.000795	.97
DD 0963	.000043	.74
DDG	.000083	.87
DDG 0993	.000996	.84
EE	-.000241	.09
EE 1052	-.000085	.09
EEG	-.000590	.04*
EEG 0007	-.000570	.24
LCC	-.000181	.47
LHA	-.001012	.07
LPD	-.000118	.18
LPH	.000488	.99
LSD	.000026	.56
LST	.000177	.92

λ_1 - Failure Rate w/o OMT

λ_2 - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

1. Trained Units in Control Group

The results in Table 3 reproduced here from Chapter I, Table 4, and Table 7 through 9 represent analysis of the three data bases produced considering only units on which OMT was conducted. These results demonstrate the net positive effect of OMT on improving equipment reliability. This positive effect is not found to be statistically significant at accepted levels of significance ($\alpha \leq .1$), however the overall effect is none-the-less very positive.

With this experimental design 61 percent of ship classes, 65 percent of EICs, and in fully 70 percent of OMT training events studied exhibit an improvement in equipment reliability for up to three years after participating in this training program. Again, this more positive effect intensifies as time from the training date increases.

The concentration of OMT training events in a few classes of ships biases class-wide results. The more important observation is what effect does OMT have on reliability of types of equipments regardless of the platform on which it is installed. Of

equal importance is the question of what areas and courses, produce the greatest impact on equipment reliability. For these two topics a more realistic analysis of training events by course is provided. Results in this section will be presented with the more meaningful course statistics preceding the unevenly weighted class tables.

2. All Units in Control Group

Table 5, Table 6, and Table 10 through Table 12 are the analysis of the three summed failure rate data bases produced incorporating all ships, trained and non-trained, into the control group. As previously mentioned the numbers of classes displaying positive effects increases with longer time horizons. Actual failure rates in failures per equipment day are provided in Table 6 with rate differences. The extremely small size of the fractions involved in some cases create havoc with tests for significance. For example in Table 5 only five of the eleven courses studied show a positive effect and none are significant at $\alpha \leq .1$, these five include 53.4 percent of the training conducted. The electric motor course comprises another 17 percent of the training events and a negligible difference of .000004 or 1 failure in 250,000 equipment days moves this course into the negative effect category.

TABLE 5
FAILURE RATES BY COURSE (ALL UNITS, 3 YEAR TIME HORIZON)

COURSE	PVALUE	λ_1	λ_2	$\lambda_1 - \lambda_2$
AC&R	.97	.000425	.000375	.000050
AIR COMP	1.00	.002923	.002297	.000626
CENTPUMP	.58	.000625	.000618	.000007
DE	.19	.000225	.000257	-.000031
DRY AIR	.46	.000595	.000574	.000022
ELEC MOT	.37	.000033	.000036	-.000004
FIRE	.99	.000128	.000054	.000074
MK 19	.02*	.000428	.000575	-.000147
STEAMVAL	.03*	.000432	.000529	-.000097
60/400HZ	.09	.001499	.001852	-.000353
60/400MG	.00*	.001128	.001673	-.000545
λ_1 - Failure Rate w/o OMT				
λ_2 - Failure Rate /w OMT				
* significant ($\alpha \leq .1$)				

By further dividing OMT courses into specific EICs, fully 60 percent of equipments enjoy improved reliability as a result the training. Only six EICs display significant negative effects of the 65 found to exist on classes of ships studied.

TABLE 6
FAILURE RATES BY CLASS (ALL UNITS, 3 YEAR TIME HORIZON)

CLASS	PVALUE	λ_1	λ_2	$\lambda_1 - \lambda_2$
AD	.01*	.000483	.000735	-.000252
AE	.88	.000395	.000324	-.000071
AO	.10	.000620	.000792	-.000172
AOR	.57	.000478	.000454	-.000024
AR	.15	.000572	.000751	-.000179
CG	.96	.000735	.000633	-.000102
CGN	.99	.000812	.000337	-.000475
DD	.29	.000420	.000477	-.000057
DD 0963	.78	.000376	.000343	-.000032
DDG	.97	.000640	.000568	-.000072
DDG 0993	.00*	.000785	.002059	-.001274
FE	.01*	.000724	.000910	-.000185
FE 1052	.45	.000435	.000438	-.000003
FFG	.73	.000929	.000801	-.000129
FFG 0007	.00*	.002552	.004351	-.001799
LCC	.04*	.000782	.001337	-.000555
LHA	.00*	.000796	.002708	-.001912
LPD	.34	.000754	.000780	-.000026
LPH	.86	.000852	.000739	-.000113
LSD	.00*	.000419	.000683	-.000264
LST	.40	.000423	.000436	-.000013

λ_1 - Failure Rate w/o OMT

λ_2 - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

In the final chapter conclusions and recommendations based on these results be presented and discussed.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This study has attempted to be an unbiased evaluation of the impact onboard maintenance training has on equipment reliability on several classes of U.S. Navy surface ships. The results presented in this thesis demonstrate that specific OMT courses produce improved reliability on certain equipment. While this effect is not statistically significant at normally recognized levels, the positive effect is measurable.

It appears that this positive effect manifests itself in two interesting ways. First, it is observed when failure rates are compared before and after training (trained units only in control group) rather than comparing trained ship failure rates with those of non-trained ships. One rationale for this result is that ships participating in OMT have a real need for the training. It is reasonable to assume that a unit experiencing problems with certain types of equipment, without sufficiently trained maintenance personnel to elevate the situation, i.e. higher failure rates, would benefit the most from training such as that provided by OMT.

The second phenomenon observed is most probably caused by an aberration in the CASREPT data used for this study. The observation that trained units failure rates improve as the duration of time from the training date was initially counter-intuitive. An understanding of the CASREPT file produces the most likely answer. There is more than one piece of equipment of a particular EIC on each ship. However these equipments are not differentiated in the CASREPT data studied. In reality failure rates were computed in failures per ship EIC days rather than equipment days. As all ships and EICs were treated uniformly the comparisons of these values remain insightful, but not perfect. This improvement with time effect could result from OMT ships exercising new found talents of repair on identical types and identification coded equipments shortly following completion of the training course. The fact that these repairs often require more than 48 hour duration, results in a CASREPT being filed and this studies trained failure rate rising during the first year. Including a specific equipment identifier in the CASREPT data which is included as part of the required message format would correct this problem.

Onboard Maintenance Training makes good sense from both an economic and personnel productivity view point. Equipment is repaired to class C overhaul standards at a fraction of the expense of having it done off the ship, and very expensive specialized skill training is conducted again at a fraction of the off ship cost. While it was beyond the scope of this thesis to produce a cost benefit analysis of the training costs involved, the economics of embedded training over off ship training appear significant.

Based on this evaluation of the quantifiable variables and an application of principles discussed in Chapter III this author concludes that OMT has a definite net positive effect on both Navy readiness and budget efficiency.

B. RECOMMENDATIONS

1. For Further Studies

The uses of the data bases created in this thesis abound. Possible uses include:

- Inclusion of an OMT training variable in a multivariate analysis of ship readiness.
- Conduct an extensive cost study of Navy specialized training and OMT.
- Analysis of the pre-test post-test data contained in the OMT Student Detail section of the Unified data.
- Analysis of the parts, tools, and technical documentation onboard sections of the OMT Ship Detail file.
- Use of the SQIP training records and IMA production records to evaluate training efficiency.
- SQIP Student Detail pre-test and post-test as for OMT.
- Correct the equipment identification problem in the CASREPT data encountered during this thesis and rerun this study.
- Use the CASREPT file as a dependent variable in other studies.

2. For Onboard Maintenance Training

It is the strong recommendation of this author that Onboard Maintenance Training be expanded to include not only engineering skill areas but also weapons, communications, and electronic repair. Increased funding for this expansion of OMT could be provided by transfer of a portion of existing Type Commander maintenance funds. With rising shipyard manhour costs and existing civilian contracted repair costs, OMT is a more productive use of each Type Commander repair dollar than any other alternative.

APPENDIX A

RECORD LAYOUT FOR UNIFIED INDUSTRIES DATA

This is the layout for the Unified Industries data base. There are six sub files contained within this data base. Particular data sets are differentiated by the contents of positions one and two.

1. SHIP MASTER

DATA SET NUMBER	PIC X(02) VALUE '01'
HULL/TYPE	PIC X(9)
FILLER	PIC X
SHIP NAME	PIC X(20)
FLEET	PIC X(8)

2. SQIP MASTER

DATA SET NUMBER	PIC X (02) VALUE '02'
SQIP COURSE CODE	PIC X (8)
SQIP COURSE NAME	PIC X (29)
FILLER	PIC X

3. OMT MASTER

DATA SET NUBMER	PIC X (02) VALUE '03'
OMT COURSE CODE	PIC X (8)
OMT COURSE NAME	PIC X (25)
FILLER	PIC X

4. SQIP STUDENT DETAIL

DATA SET NUMBER	PIC X (02) VALUE '04'
STUDENT NAME	PIC X (14)
NAVY RATE	PIC X (4)
E RATE	PIC XX
HULL TYPE	PIC X (9)
FILLER	PIC X
SQIP COURSE CODE	PIC X (8)
SQIP COURSE TYPE	PIC X (4)
SQIP COURSE TYPE-G	REDEFINES
FILLER	PIC XX
INITIAL VISIT	VALUE "IV"
REVISIT	VALUE "RV"
FOLLOW ON VISIT	VALUE "FO"
FILLER	PIC XX
BEGINNING DATE	PIC 9 (6)
ENDING DATE	PIC 9 (6)
LOCATION	PIC X (12)
INSTRUCTOR	PIC X (14)
COMPLETION CODE	PIC X
FILLER	PIC X
WRITTEN PRE TEST	PIC 999 COMP
WRITTEN POST TEST	PIC 999 COMP
HANDS-ON PRE TEST	PIC 999 COMP
HANDS-ON POST TEST	PIC 999 COMP
HOURS LECTURE	PIC 99 COMP 8 TIMES
HOURS OJT	PIC 99 COMP 8 TIMES

5. OMT STUDENT DETAIL

DATA SET NUMBER	PIC X (02) VALUE '05'
STUDENT NAME	PIC X (14)
NAVY RATE	PIC X (4)
E RATE	PIC XX
PRD	PIC 9 (4) COMP
HULL TYPE	PIC X (9)
FILLER	PIC X
OMT COURSE CODE	PIC X (8)
FILLER	PIC XX
BEGINNING DATE	PIC 9 (6)
ENDING DATE	PIC 9 (6)
LOCATION	PIC X (12)
INSTRUCTOR	PIC X (14)
COMPLETION CODE	PIC X
FILLER	PIC X
WRITTEN PRE TEST	PIC 999 COMP
WRITTEN POST TEST	PIC 999 COMP
HANDS-ON PRE TEST	PIC 999 COMP
HANDS-ON POST TEST	PIC 999 COMP
HOURS LECTURE	PIC 99 COMP 8 TIMES
HOURS OJT	PIC 99 COMP 8 TIMES

6. OMT SHIP DETAIL

DATA SET NUBMER	PIC X (02) VALUE '06'
HULL TYPE	PIC X (9)
FILLER	PIC X
OMT COURSE CODE	PIC X (8)
OMT COURSE TYPE	PIC XX
INITIAL VISIT	VALUE "IV"
FOLLOW-ON VISIT	VALUE "FO"
BEGINNING DATE	PIC 9 (6)
ENDING DATE	PIC 9 (6)
FOLLOW-ON DATE	PIC 9 (6)
LOCATION	PIC X (12)
INSTRUCTOR	PIC X (14)
REMAINING ONBOARD	PIC 999 COMP
ONGOING TRAINING	PIC X
FILLER	PIC X
INSTRUCTORS GUIDE	PIC X
FILLER	PIC X
SIMILAR REPAIRED	PIC 999 COMP
NO MORE REPAIR	PIC 999 COMP
DEF DATA	
TOOLS PRE	PIC 9 (4)
TOOLS POST	PIC 9 (4)
TECH DOC PRE	PIC 9 (4)
TECH DOC POST	PIC 9 (4)
REPAIR PARTS PRE	PIC 9 (4)
REPAIR PARTS POST	PIC 9 (4)
REPAIR DATA	
COMPLETE REPAIRS	PIC 99
AWAITING PARTS	PIC 99
REQUIRE IMA	PIC 99

REQUIRE DEPOT	PIC 99
NOT ENOUGH TIME	PIC 99

7. SAMPLE OF UNIFIED SHIP DETAIL FILE

06DD-963	60/400HZIV821122821203000000ATLANTIC	CEWARD
06DD-963	ELEC MOTIV821220821230000000ATLANTIC	CEWARD
06DD-963	ELEC MOTIV831107831118000000ATLANTIC	J PINKER
06DD-963	STEAMVALIV831031831118000000ATLANTIC	JEHUDSON
06DD-963	AC&R IV831107831125000000ATLANTIC	C CONLEY
06DD-964	CENTPUMPIV850624850628000000PACIFIC	M LINCOL

8. SAMPLE OF CASREPT FILE

20574DD	096382100601500320128211020322800280026000210624	1S5HEG
20574DD	096382100720200320228210210321600150000001510000	OR3550
20574DD	096382101321160320828301220330901020000010210000	1SQM59
20574DD	096382101502160321028301250331201030018008510432	2RGWFC
20574DD	096382101811500321328211100323600240019000510456	1RG321

APPENDIX B

TAPE READING TO MASS STORAGE SYSTEM

1. UNIFIED DATA TO MASS STORAGE

```
//NPS528 JOB (2908,9999),'X0002 TAPE1',CLASS=E
//*MAIN RINGCHK=NO
// EXEC PGM=IEBGENER
//SYSPRINT DD SYSOUT=A
//SYSIN DD DUMMY
//SYSUT1 DD DISP=SHR,DSNAME=MSS.S2908.UNIFIED
//SYSUT2 DD UNIT=3400-6,VOL=SER=NPS528,DISP=(NEW,PASS),
//          LABEL=(1,NL,,OUT),
//          DCB=(RECFM=FB,LRECL=200,BLKSIZE=19000,DEN=3)
```

2. CASREPT TAPE TO MASS STORAGE

```
//X0003 JOB (2908,9999),'X0003 FORTRAN',CLASS=F
// EXEC FORTVCG
//FORT.SYSIN DD *
//          CHARACTER*57 A
//          CHARACTER*20 B
//          CHARACTER*1 BLK
//          DATA BLK/' '/
//          INDEX = 0
10 CONTINUE
   READ(1,20,END=100) A,B
20 FORMAT(A57,1X,A20)
   INDEX = INDEX + 1
   WRITE(2,30) A,BLK,B
30 FORMAT(A57,A1,A20)
   GO TO 10
100 CONTINUE
   WRITE(6,110) INDEX
110 FORMAT(1X,'RECORDS TRANSFERRED:',I8)
   STOP
   END
/*
//GO.FT01F001 DD UNIT=3400-6,VOL=SER=X0003,DISP=(OLD,PASS),
//          LABEL=(1,NL,,IN),
//          DCB=(RECFM=FB,LRECL=78,BLKSIZE=780,DEN=3,OPTCD=Q)
//GO.FT02F001 DD DISP=(OLD,KEEP),
//          DCB=(RECFM=FB,LRECL=78,BLKSIZE=19032),
//          DSN=MSS.S2908.CASREP
```

3. SELECT OMT SHIP MASTER AND SHIPS STUDIED FROM UNIFIED FILE

```
//UNIFIED JOB (2908,9999), 'UNIFIED SPSSX', CLASS=A
// EXEC SPSSX
//DD1 DD DISP=SHR,DSN=MSS.S2908.UNIFIED
//DD2 DD UNIT=SYSDA,DISP=(OLD,KEEP),
// DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020),
// SPACE=(19020,(4,1)),DSN=MSS.S2908.SUBSET.UNIFIED
//SYSIN DD *
DATA LIST FILE=DD1 / TYPE 1-2 CLASS 3-5(A) COURSE 13-20(A)
      BEGDATE 23-28(A) ENDDATE 29-34(A) LOCAL 41-48(A) INSTRUCT 53-60(A)
      XXX 1-60(A)
SELECT IF (TYPE EQ 06)
IF (CLASS EQ 'AD-') FLAG = 1
IF (CLASS EQ 'AE-') FLAG = 1
IF (CLASS EQ 'AO-') FLAG = 1
IF (CLASS EQ 'AOR') FLAG = 1
IF (CLASS EQ 'AR-') FLAG = 1
IF (CLASS EQ 'CGN') FLAG = 1
IF (CLASS EQ 'DDG') FLAG = 1
IF (CLASS EQ 'FFG') FLAG = 1
IF (CLASS EQ 'FF-') FLAG = 1
IF (CLASS EQ 'DD-') FLAG = 1
IF (CLASS EQ 'CG-') FLAG = 1
IF (CLASS EQ 'LCC') FLAG = 1
IF (CLASS EQ 'LKA') FLAG = 1
IF (CLASS EQ 'LPD') FLAG = 1
IF (CLASS EQ 'LPH') FLAG = 1
IF (CLASS EQ 'LSD') FLAG = 1
IF (CLASS EQ 'LST') FLAG = 1
SELECT IF (FLAG = 1)
WRITE OUTFILE=DD2 / XXX 1-60 (A)
EXECUTE
/*
```

4. UNIFIED DATA FREQUENCIES

OCLASS

0

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
	AD	16	1.4	1.4	1.4
	AE	56	4.8	4.8	6.1
	AO	16	1.4	1.4	7.5
	AOR	34	2.9	2.9	10.4
	AR	20	1.7	1.7	12.1
	CG	111	9.4	9.4	21.5
	CGN	24	2.0	2.0	23.6
	DD	185	15.7	15.7	39.3
	DDG	175	14.9	14.9	54.2
	FF	214	18.2	18.2	72.4
	FFG	54	4.6	4.6	77.0
	LCC	14	1.2	1.2	78.1
	LKA	7	.6	.6	78.7
	LPD	71	6.0	6.0	84.8
	LPH	54	4.6	4.6	89.4
	LSD	55	4.7	4.7	94.0
	LST	70	6.0	6.0	100.0
		-----	-----	-----	
OVALID CASES	1176	TOTAL	1176	100.0	100.0
MISSING CASES	0				

OCOURSE

0

VALUE LABEL	VALUE	FREQUENCY	PERCENT	VALID PERCENT	CUM PERCENT
	AC&R	196	16.7	16.7	16.7
	AIR COMP	165	14.0	14.0	30.7
	CENTPUMP	181	15.4	15.4	46.1
	DE	46	3.9	3.9	50.0
	DRY AIR	22	1.9	1.9	51.9
	ELEC MOT	204	17.3	17.3	69.2
	FIRE	64	5.4	5.4	74.7
	MK 19	30	2.6	2.6	77.2
	STEAMVAL	218	18.5	18.5	95.7
	60/400HZ	35	3.0	3.0	98.7
	60/400MG	15	1.3	1.3	100.0
		-----	-----	-----	
OVALID CASES	1176	TOTAL	1176	100.0	100.0
		MISSING CASES	0		

5. SELECT SHIPS AND EICS STUDIED FROM CASREPT FILE

```
//CASREPT JOB (2908,9999), 'CASREP SPSSX', CLASS=G
// EXEC SPSSX
//DD1 DD DISP=SHR,DSN=MSS.S2908.CASREP
//DD2 DD UNIT=SYSDA,DISP=(NEW,CATLG),
//      DCB=(RECFM=FB,LRECL=64,BLKSIZE=19008),
//      SPACE=(19008,(400,40)),
//      DSN=MSS.S2908.SUBSET.CASREP
//SYSIN DD *
DATA LIST FILE=DD1 /UIC 1-5 CLASS 6-9(A) HULL 10-13 BEGDATE 14-19
MAINDOWN 49-52 OPEN 53 CAUSE 59(A) REPLVL 60(A) EIC 61-64(A)
TOTDOWN 41-44 SUPDOWN 45-48 SHIP 6-13(A)
XXX 1-64(A)
IF (CLASS EQ 'AD' ) FLAG = 1
IF (CLASS EQ 'AE' ) FLAG = 1
IF (CLASS EQ 'AO' ) FLAG = 1
IF (CLASS EQ 'AOR' ) FLAG = 1
IF (CLASS EQ 'AR' ) FLAG = 1
IF (CLASS EQ 'CGN' ) FLAG = 1
IF (CLASS EQ 'DDG' ) FLAG = 1
IF (CLASS EQ 'FFG' ) FLAG = 1
IF (CLASS EQ 'FF' ) FLAG = 1
IF (CLASS EQ 'DD' ) FLAG = 1
IF (CLASS EQ 'CG' ) FLAG = 1
IF (CLASS EQ 'LCC' ) FLAG = 1
IF (CLASS EQ 'LKA' ) FLAG = 1
IF (CLASS EQ 'LPD' ) FLAG = 1
IF (CLASS EQ 'LPH' ) FLAG = 1
IF (CLASS EQ 'LSD' ) FLAG = 1
IF (CLASS EQ 'LST' ) FLAG = 1
SELECT IF (FLAG = 1)
SELECT IF ANY (EIC, TF01, TF03, TF04, CC01, CC03, EB03, KF01,
'KF03', TLOF, TLOG, TLOH, TLOJ, LB0M, LB0N, LB0P, LB0Q,
'K703', K705, F703, F705, 4708, 4704, 4703, F301, F303,
'F308', F309, F30A, F30C, F30D, F30E, F30G, F30H, FB01,
'FB05', FB06, FB07, E901, E905, E907, E909, K301, K303,
'K308', K309, K30A, K30C, K30D, K30E, K30G, K30H, KAC1,
'KA05', KA06, KA07, T707, T708, T401, T403, T404, T405,
'T406', T407, T408, T409, T40S, T40T, T501, T504, N4C1,
'N403', N404, N405, N406, N407, N408, N409, N40A, N40B,
'N40C', N40D, N40E, N40F, N40G, N40H, N40J, N40K, N40L,
'N40M', N40N, N40P, N40Q, N40R, N40S, N40T, N40U, N40V,
'N40W', N40X, T901, T903, T904, T405, T906, T907, T908,
'T909', T911, T90A, T90C)
WRITE OUTFILE=DD2 / XXX 1-64 (A)
EXECUTE
/*
```

APPENDIX C

UNIFIED DATA TRANSFORMATION

```
//RDDATA JOB (2908,9999),'RDDATA FORTRAN',CLASS=A
// EXEC FORTVCG
//FORT.SYSIN DD *
  CHARACTER*1 BLK,DASH,B2
  CHARACTER*2 B1
  CHARACTER*4 UTP(1351),UNUM(1351)
  CHARACTER*3 UCNAME(1351),C2
  CHARACTER*9 CC
  INTEGER UYR(1351),UMON(1351),UDAY(1351),UDATE(1351)
  INTEGER NDAYS(12)
  DATA NDAYS/0,31,59,90,120,151,181,212,243,273,304,334/
  DATA BLK/' ','/',DASH/'-'/
  DATA UTP/1351*' '/
  DATA UNUM/1351*'0000'/
  I=1
1 CONTINUE
2 FORMAT(A2,A4,A4,A1,A8,A8,I5)
  READ(1,5,END=9) B1,CC,B2,UCNAME(I),C2,UYR(I),UMON(I),UDAY(I)
5 FORMAT(A2,A9,A1,A8,A8,I2,I2,I2)
  IF(UYR(I).EQ.0) GO TO 1
  JJ=0
  J2=0
  DO 7 J=1,9
    J2=J2+1
    IF (JJ.GT.0) GO TO 6
    ID=J
    IF (CC(J:J).EQ.DASH) GO TO 6
    UTP(I)(1:J)=CC(1:J)
    GO TO 7
6 CONTINUE
  JJ=JJ+1
  IF(CC(J:J).EQ.BLK) GO TO 8
7 CONTINUE
8 CONTINUE
  UNUM(I)(7-JJ:4)=CC(ID+1:J2-1)
  UDATE(I)=(UYR(I)-74)*365+NDAYS(UMON(I))+UDAY(I)
  WRITE(2,2)B1,UTP(I),UNUM(I),B2,UCNAME(I),C2,UDATE(I)
  I=I+1

  GO TO 1
9 CONTINUE
  WRITE(6,110) I-1
110 FORMAT(1X,'RECORDS TRANSFERRED:',I8)
  STOP
  END

/*
//GO.FT01F001 DD DISP=(OLD,KEEP),
// DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020),
// DSN=MSS.S2908.SUBSET.UNIFIED
//GO.FT02F001 DD DISP=(NEW,CATLG,DELETE),SPACE=(19020,(40,10)),
// DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020)
// DSN=MSS.S2908.SUBSET.UNIFIED1,UNIT=SYSDA
***** SORT SUBSET.UNIFIED ONE BY SHIP, COURSE, AND DATE

//UNIFIED JOB (2908,9999),'UNIFIED SPSSX',CLASS=B
// EXEC SPSSX
//DD1 DD DISP=SHR,DSN=MSS.S2908.SUBSET.UNIFIED1
//DD2 DD UNIT=SYSDA,DISP=(OLD,KEEP),
// DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020),
// SPACE=(19020,(4,1)),DSN=MSS.S2908.SUBSET.UNIFIED2
//SYSIN DD *
```

DATA LIST FILE=DD1 / TYPE 1-2 SHIP 3-10(A) COURSE 12-19(A)
UPDATE 29-32 XXX 1-60(A)
SORT CASES BY SHIP(A) COURSE(A) UPDATE(A)
WRITE OUTFILE=DD2 / XXX 1-60 (A)
EXECUTE
/*
//

APPENDIX D COMBINED CASREPT AND OMT FILE

```
//DATA JOB (2908,9999),'EIC FORTRAN',CLASS=J
// EXEC FORTVCLG,REGION.GO=1500K
//FORT.SYSIN DD *
PARAMETER (NEIC=110,NSHIP=700)
CHARACTER*1 B2,REP(500)
CHARACTER*2 B1
CHARACTER*4 UTYP(1351),UNUM(1351),EICTBL(NEIC),CEIC(500)
CHARACTER*5 A1
CHARACTER*6 D1,E1
CHARACTER*8 UCNAME(1351),C2,CRSTBL(NEIC),SHIP(NSHIP),USHIP(1351),
.CSHIP(500)
CHARACTER*9 CC
CHARACTER*10 C1
INTEGER UYR(1351),UMON(1351),UDAY(1351),UPDATE(1351),CBDATE(500),
.FLT(500),CEDATE(500),TDOWN(500),SDOWN(500),MDOWN(500),CENSOR(500)
INTEGER ITABLE(NSHIP,NEIC)
DATA EICTBL/'TF01','TF03','TF04','CC01','CC03','EB03','KF01',
.'KF03','TLOF','TLOG','TLOH','TLOJ','LBOM','LBON','LBOP','LB00',
.'K703','K705','F703','F705','4708','4704','4703','F301','F303',
.'F308','F309','F30A','F30C','F30D','F30E','F30G','F30H','FB01',
.'FB05','FB06','FB07','E901','E905','E907','E909','K301','K303',
.'K308','K309','K30A','K30C','K30D','K30E','K30G','K30H','KA01',
.'KA05','KA06','KA07','T707','T708','T401','T403','T404','T405',
.'T406','T407','T408','T409','T40S','T40T','T501','T504','N401',
.'N403','N404','N405','N406','N407','N408','N409','N40A','N40B',
.'N40C','N40D','N40E','N40F','N40G','N40H','N40J','N40K','N40L',
.'N40M','N40N','N40P','N40Q','N40R','N40S','N40T','N40U','N40V',
.'N40W','N40X','T901','T903','T904','T405','T906','T907','T908',
.'T909','T911','T90A','T90C'/
DATA CRSTBL/ 2*'AIR COMP',1*'DRY AIR',9*'ELEC MOT',4*'MK 19', X0000070
. 4*'STEAMVAL',1*'60/400HZ',2*'60/400MG',34*'CENTPUMP',
.12*'AC&R',30*'DE',11*'FIRE'/'
JSHIP=0
LSHIP=0
DO 100 I=1,1351
READ(1,2,END=110)B1,USHIP(I),B2,UCNAME(I),C2,UPDATE(I)
2 FORMAT(A2,A8,A1,A8,A8,I5)
3 FORMAT(1X,'JSHIP'=',I4)
4 FORMAT(A5,A8,A10,I5,I1,A6,I5,I4,I4,I4,I1,A6,A1,A4)
5 FORMAT(A8,1X,I5,1X,I1,1X,I5,1X,3(I4,1X),I1,1X,A1,1X,A4,1X,I1)
6 FORMAT(1X,'JSHIP',1X,'SHIP',',',NCASRP')
7 FORMAT(1X,I4,2X,A8,2X,I4)
C TEST FOR NEW SHIP
DO 10 J=1,NSHIP
IF (SHIP(J).EQ.USHIP(I))THEN
JJ=J
GO TO 20
ENDIF
10 CONTINUE
C NEW SHIP
JSHIP=JSHIP+1
IF (JSHIP.GT.NSHIP)STOP 'JSHIP.GT.NSHIP'
JJ=JSHIP
SHIP(JSHIP)=USHIP(I)
20 CONTINUE
C MAKE SHIP/EIC TABLE
DO 30 J=1,NEIC
IF (UCNAME(I).EQ.CRSTBL(I)) THEN
ITABLE(JJ,J)=1
END IF
30 CONTINUE
```

```

        WRITE(6,3)JSHIP
100  CONTINUE
110  CONTINUE
C    READ CASREP FILE AND PROCESS DATA FOR ONE SHIP AT A TIME
        I=0
        DO 1000 K=1,150000
200  CONTINUE
        I=I+1
        READ(2,4,END=280)A1,CSHIP(I),C1,CBDATE(I),FLT(I),D1,CEDATE(I),
        ,TDOWN(I),SDOWN(I),MDOWN(I),CENSOR(I),E1,REP(I),CEIC(I)
250  CONTINUE
        IF(I.EQ.1) THEN
            C2=CSHIP(I)
        ELSE
            IF(CSHIP(I).NE.C2) GO TO 300
        ENDIF
        GO TO 200
280  CONTINUE
        LSHIP=1
300  CONTINUE
        NCASRP=I-1
        DO 500 J=1,NSHIP
            IF(C2.EQ.SHIP(J)) THEN
                JSHIP=J
                GO TO 510
            ENDIF
500  CONTINUE
510  CONTINUE
        DO 700 N=1,NCASRP
            DO 600 J=1,NEIC
                IF(CEIC(N).EQ.EICTBL(I)) THEN
                    JEIC=J
                    GO TO 610
                ENDIF
600  CONTINUE
610  CONTINUE
        JDUM=ITABLE(JSHIP,JEIC)
        WRITE(3,5)CSHIP(N),CBDATE(N),FLT(N),CEDATE(N),TDOWN(N),SDOWN(I),
        ,MDOWN(N),CENSOR(N),REP(N),CEIC(N),JDUM
700  CONTINUE
        WRITE(6,6)
        WRITE(6,7) JSHIP,C2,NCASRP
C    START NEW SHIP
        I=1
        CSHIP(I)=CSHIP(NCASRP+1)
        CBDATE(I)=CBDATE(NCASRP+1)
        FLT(I)=FLT(NCASRP+1)
        CEDATE(I)=CEDATE(NCASRP+1)
        TDOWN(I)=TDOWN(NCASRP+1)
        SDOWN(I)=SDOWN(NCASRP+1)
        MDOWN(I)=MDOWN(NCASRP+1)
        CENSOR(I)=CENSOR(NCASRP+1)
        REP(I)=REP(NCASRP+1)
        CEIC(I)=CEIC(NCASRP+1)
        IF(LSHIP.EQ.1)GO TO 1100
        GO TO 250
1000 CONTINUE
1100 CONTINUE
        STOP
        END

```

X0000190
X0000200

```

/*
//GO.FT01F001 DD DISP=SHR,
//  DSN=MSS.S2908.SUBSET.UNIFIED1
//GO.FT02F001 DD DISP=(OLD,KEEP),
//  DSN=MSS.S2908.SUBSET.CASREP
//GO.FT03F001 DD DISP=(NEW,CATLG),SPACE=(19032,(304,10)),
//  DCB=(RECFM=FB,LRECL=78,BLKSIZE=19032),
//  UNIT=SYSDA,
//  DSN=MSS.S2908.OMT

```

1. EXAMPLE OF COMBINED CASREPT AND OMT FILE

The following is an example of the output of the combined CASREPT and OMT program. Note this output is for only two ships in the DD 0963 class.

DD	0963	3529	2	3536	8	0	8	1	T	LBCM	0	0	0
DD	0963	3250	2	3323	74	72	2	1	S	N40S	0	0	0
DD	0963	3213	2	3276	64	59	5	1	S	TF01	0	0	0
DD	0963	3370	6	3381	12	10	2	1	S	TF01	0	18	0
DD	0963	3445	6	3466	22	19	3	1	S	TF01	0	64	0
DD	0963	3592	2	3643	52	0	52	1	R	TF01	0	126	0
DD	0963	3806	2	3808	3	0	3	1	S	TF01	0	163	0
DD	0963	3813	2	3821	9	0	9	1	T	TF01	0	5	0
DD	0963	3398	2	3920	23	0	23	1	T	TF01	0	48	0
DD	0963	3922	2	3927	6	3	3	1	R	TF01	0	2	0
DD	0963	4232	2	4253	22	0	22	1	S	TF01	0	305	3614
DD	0963	4328	2	4354	27	24	3	1	S	TF01	0	44	3614
DD	0963	4360	2	4372	13	5	8	1	T	TF01	0	6	3614
DD	0963	3323	6	3364	42	18	24	1	S	TF03	0	0	0
DD	0963	3385	6	3403	19	0	19	1	S	TF03	0	21	0
DD	0963	3754	2	3771	18	0	18	1	S	TF03	0	351	0
DD	0963	3807	2	3833	77	0	77	1	T	TF03	0	36	0
DD	0963	3916	2	3922	7	0	7	1	S	TF03	0	102	0
DD	0963	3922	2	3927	6	2	4	1	R	TF03	0	0	0
DD	0963	4179	2	4265	87	0	87	1	S	TF03	0	252	3614
DD	0963	4265	2	4324	60	0	60	1	S	TF03	0	8	3614
DD	0963	4320	2	4354	35	29	6	1	S	TF03	0	47	3614
DD	0963	3626	2	3662	37	23	14	1	T	TF04	0	0	0
DD	0963	4265	2	4313	49	0	49	1	R	T40S	1	0	3614
DD	0963	4367	2	4536	170	0	170	1	S	T40S	1	54	3614
DD	0963	4126	6	4159	34	0	34	1	S	T40S	1	0	3614
DD	0964	3235	3	3264	30	28	2	1	S	TF01	0	0	0
DD	0964	3677	3	3684	8	1	7	1	T	TF01	0	413	0
DD	0964	3711	3	3747	37	34	3	1	R	TF01	0	27	0
DD	0964	3837	3	3890	54	52	2	1	S	TF01	0	90	0
DD	0964	4099	3	4130	32	0	32	1	T	TF01	0	209	0
DD	0964	4270	3	4272	3	0	3	1	S	TF01	0	140	0
DD	0964	3516	3	3530	15	10	5	1	S	TF03	0	0	0
DD	0964	3541	3	3545	5	0	5	1	T	TF03	0	11	0
DD	0964	3623	3	3671	49	43	6	1	S	TF03	0	78	0
DD	0964	3741	3	3762	22	17	5	1	S	TF03	0	69	0
DD	0964	3776	3	3892	117	67	50	1	S	TF03	0	14	0
DD	0964	4838	3	4838	1	0	1	0	S	TF03	0	919	0
DD	0964	3656	3	3727	72	7	65	1	T	T40S	0	0	0
DD	0964	3237	3	3300	64	0	64	1	R	T40S	0	0	0
DD	0964	3967	3	4109	123	0	123	1	R	T40S	0	687	0
DD	0964	4209	3	4270	62	0	62	1	T	T40S	0	100	0
DD	0964	4582	3	4606	25	0	25	1	S	T40S	0	179	0
DD	0964	3811	3	3814	4	2	2	1	S	T504	0	0	0
DD	0964	3588	3	3610	23	21	2	1	S	T708	0	0	0
DD	0964	3213	3	3242	30	0	30	1	R	4708	0	0	0

APPENDIX E

SUMMED FAILURE RATE PROGRAMS

1. ALL UNITS INCLUDED IN CONTROL GROUP

This program uses all ships of interest when generating control group failure rates.

```
//DATA JOB (2908,9999), 'FAILURE RATE', CLASS=G
// EXEC FORTVCLG, REGION.GO=15COK
//FORT.SYSIN DD *
PARAMETER (NEIC=111, NSHIP=700, NCS=900, NCL=22)
CHARACTER*1 B2, REP(NCS)
CHARACTER*2 B1
CHARACTER*4 EICTBL(NEIC), CEIC(NCS)
CHARACTER*5 A1
CHARACTER*6 D1, E1
CHARACTER*8 UCNAME(1351), C2, CRSTBL(NEIC), SHIP(NSHIP), USHIP(1351),
.CSHIP(500), CLASS(NCL+1)
CHARACTER*10 C1
INTEGER UDATE(1351), CBDATE(NCS),
.FLT(NCS), CEDATE(NCS), TDOWN(NCS), SDOWN(NCS), MDOWN(NCS), CENSOR(NCS)
INTEGER ICCOUNT(2, NEIC), ITIME(2, NEIC), ITRAIN
.(NEIC), LUDATE(NEIC), ITOTAL(2, NEIC), ITOTTM(2, NEIC)
DATA EICTBL/ TF01' TF03' TF04' CC01' CC03' EB03' KF01'
.KF03' TLOF' TLOG' TLOH' TLOJ' LBOM' LBON' LBOP' LB00'
.K703' K705' F703' F705' 4708' 4704' 4703' F301' F303'
.F308' F309' F30A' F30C' F30D' F30E' F30G' F30H' FB01'
.FB05' FB06' FB07' E901' E905' E907' E909' K301' K303'
.K308' K309' K30A' K30C' K30D' K30E' K30G' K30H' KA01'
.KA05' KA06' KA07' T707' T708' T401' T403' T404' T405'
.T406' T407' T408' T409' T40S' T40T' T501' T504' N401'
.N403' N404' N405' N406' N407' N408' N409' N40A' N40B'
.N40C' N40D' N40E' N40F' N40G' N40H' N40J' N40K' N40L'
.N40M' N40N' N40P' N40Q' N40R' N40S' N40T' N40U' N40V'
.N40W' N40X' T901' T903' T904' T405' T906' T907' T908'
.T909' T911' T90A' T90C' /
DATA CRSTBL/ 2*'AIR COMP', 1*'DRY AIR', 9*'ELEC MOT', 4*'MK 19'
. 4*'STEAMVAL', 1*'60/400HZ', 2*'60/400MG', 34*'CENTPUMP',
.12*'AC&R', 30*'DE', 11*'FIRE' /
DATA CLASS/ AD' AE' AO' AOR' AR
.'CG' CGN' CV' DD' DD 0963'
.'DDG' DDG 0993' FF' FF 1052' FFG
.'FFG 0007' LCC' LHA' LPD' LPH
.'LSD' LST' ZZZZZZZZ /
C
2 FORMAT(A2, A8, A1, A8, A8, I5)
4 FORMAT(A5, A8, A10, I5, I1, A6, I5, I4, I4, I4, I1, A6, A1, A4)
6 FORMAT(1X, 'JSHIP', 1X, 'SHIP', 'NCASRP')
7 FORMAT(1X, I4, 2X, A8, 2X, I4, 2(2X, I5))
8 FORMAT(1X, A8, 2(1X, I5, 1X, I7, 1X, F8.6), 1X, A4, 1X, A8)
9 FORMAT(2X, A8, 2X, I4, 4X, I4, 2X, F12.6, 2X, 4X, I4, 2X, I4, 2X, F12.6, 1X, A4,
.2X, I5)
10 FORMAT(2X, A8, 2X, A8, 2X, I5)
11 FORMAT(2X, A8, 2X, I3, 2X, A4, 2X, A8, 6(2X, I5))
C
READ UNIFIED DATA
JSHIP=0
LSHIP=0
DO 100 I=1, 1351
READ(1, 2, END=110) B1, USHIP(I), B2, UCNAME(I), C2, UDATE(I)
C
TEST FOR NEW SHIP
DO 15 J=1, NSHIP
IF (SHIP(J).EQ.USHIP(I)) THEN
JJ=J
GO TO 20
```

```

        ENDIF
15  CONTINUE
C    NEW SHIP
    JSHIP=JSHIP+1
    IF (JSHIP.GT.NSHIP) STOP 'JSHIP.GT.NSHIP'
    JJ=JSHIP
    SHIP(JSHIP)=USHIP(I)
20  CONTINUE
100 CONTINUE
110 CONTINUE
C    READ CASREP FILE AND PROCESS DATA FOR ONE SHIP AT A TIME
    NCLASS=1
    DO 150 J=1,NEIC
        ITRAIN(J)=1
        IJDATE(J)=0
        ICOUNT(1,J)=0
        ICOUNT(2,J)=0
        ITIME(1,J)=0
        ITIME(2,J)=0
        ITOTAL(1,J)=0
        ITOTAL(2,J)=0
        ITOTTM(1,J)=0
        ITOTTM(2,J)=0
150  CONTINUE
        IJDATE=0
        JSHIP=0
        I=0
        DO 1000 K=1,90000
200  CONTINUE
            I=I+1
            READ(2,4,END=280)A1,CSHIP(I),C1,CBDATE(I),FLT(I),D1,CEDATE(I)
            ,TDOWN(I),SDOWN(I),MDOWN(I),CENSOR(I),E1,REP(I),CEIC(I)
250  CONTINUE
            IF(I.EQ.1) THEN
                C2=CSHIP(I)
            ELSE
                IF(CSHIP(I).NE.C2) GO TO 300
            ENDIF
            GO TO 200
280  CCNTINUE
        LSHIP=1
300  CONTINUE
        NCASRP=I-1
        IF (NCASRP.GT.NCS) STOP 'NCASRP.GT.NCS'
        DO 500 J=1,NSHIP
            IF(C2.EQ.SHIP(J)) THEN
                JSHIP=J
                GO TO 510
            ENDIF
500  CONTINUE
510  CONTINUE
        DO 740 N=1,NCASRP
            IJDATE=0
            MTBF=0
            JEIC=NEIC
            JDUM=0
            IF (N.EQ.1) GO TO 590
            DO 580 NN=1,N-1
                IF (CEIC(NN).EQ.CEIC(N)) THEN
                    MTBF=CBDATE(N)-CEDATE(NN)
                END IF
580  CONTINUE
590  CCNTINUE
            DO 600 J=1,NEIC-1
                IF(CEIC(N).EQ.EICTBL(J)) THEN
                    JEIC=J
                    GO TO 610
                ENDIF
600  CONTINUE
610  CONTINUE

```



```

IF(N.EQ.1.OR.LUDATE(JEIC).EQ.0)GOTO 700
IF((CBDATE(N)-LUDATE(JEIC)).GT.1095)THEN
    ITRAIN(JEIC)=1
ENDIF
700 CONTINUE
IF(JSHIP.EQ.0)GOTO 730
DO 720 I=1,1351
    IF (C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.(CBDATE(N)-
        .UPDATE(I)).GE.0.AND.(CBDATE(N)-UPDATE(I)).LE.1095) THEN
        IUPDATE=UPDATE(I)
        ITRAIN(JEIC)=2
        LUDATE(JEIC)=IUPDATE
        JDUM=1
        GO TO 730
    END IF
720 CONTINUE
730 CONTINUE
C INCREMENT COUNTER
ICOUNT(ITRAIN(JEIC),JEIC)=ICOUNT(ITRAIN(JEIC),JEIC)+1
740 CONTINUE
C END OF CASREPS
C TIME INCREMENT
DO 770 JEIC=1,NEIC
    LUDATE(JEIC)=0
    ITRAIN(JEIC)=1
    DO 750 I=1,1351
        IF(UPDATE(I).GT.4840)GO TO 750
        IF(C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.UPDATE(I).GT.
            .LUDATE(JEIC))THEN
            IF((UPDATE(I)-LUDATE(JEIC)).LT.1095)THEN
                ITIME(2,JEIC)=ITIME(2,JEIC)+UPDATE(I)-LUDATE(JEIC)
            ELSE
                ITIME(2,JEIC)=ITIME(2,JEIC)+1095
            ENDIF
            LUDATE(JEIC)=UPDATE(I)
            ITRAIN(JEIC)=2
            ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-UPDATE(I)))
        ENDIF
750 CONTINUE
760 CONTINUE
IF(ITRAIN(JEIC).EQ.2.AND.(4840-LUDATE(JEIC)).LT.1095)THEN
    ITIME(2,JEIC)=ITIME(2,JEIC)+4840-LUDATE(JEIC)-1095
ENDIF
ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-CBDATE(1)))-ITIME(2,JEIC)
770 CONTINUE
DO 780 J=1,NEIC
    IF(ITIME(1,J).GT.0) THEN
        FAIL1=FLOAT(ICOUNT(1,J))/FLOAT(ITIME(1,J))
    ELSE
        FAIL1=0.
    ENDIF
    IF(ITIME(2,J).GT.0) THEN
        FAIL2=FLOAT(ICOUNT(2,J))/FLOAT(ITIME(2,J))
    ELSE
        FAIL2=0.
    ENDIF
    IF(ITIME(2,J).EQ.0)GO TO 780
    ITOTAL(1,J)=ITOTAL(1,J)+ICOUNT(1,J)
    ITOTAL(2,J)=ITOTAL(2,J)+ICOUNT(2,J)
    ITOTTM(1,J)=ITOTTM(1,J)+ITIME(1,J)
    ITOTTM(2,J)=ITOTTM(2,J)+ITIME(2,J)
780 CCNTINUE
790 CONTINUE
C END CLASS
IF(LSHIP.EQ.1.OR.LGE(CSHIP(NCASRP+1),CLASS(NCLASS+1)))THEN
    DO 795 J=1,NEIC
        IF(ITOTTM(1,J).GT.0)THEN
            FAIL1=FLOAT(ITOTAL(1,J))/FLOAT(ITOTTM(1,J))
        ELSE
            FAIL1=0.
        ENDIF
    END DO
795 CONTINUE

```

```

      ENDIF
      IF(ITOTTM(2,J).GT.0)THEN
        FAIL2=FLOAT(ITOTAL(2,J))/FLOAT(ITOTTM(2,J))
      ELSE
        FAIL2=0.
      ENDIF
      IF((ITOTAL(1,J)+ITOTAL(2,J)+ITOTTM(2,J)).GT.0)
        WRITE(6,8)CLASS(NCLASS),ITOTAL(1,J),ITOTTM(1,J),FAIL1,ITOTAL(2,
        J),ITOTTM(2,J),FAIL2,EICTBL(J),CRSTBL(J)
C      NEW CLASS
        ITOTAL(1,J)=0
        ITOTAL(2,J)=0
        ITOTTM(1,J)=0
        ITOTTM(2,J)=0
795      CONTINUE
        IF(LSHIP.EQ.1)GOTO 1100
        NCLASS=NCLASS+1
        IF(NCLASS.GT.NCL)STOP 'NCLASS.GT.NCL'
      ENDIF
C      START NEW SHIP
      DO 800 J=1,NEIC
        ITRAIN(J)=1
        LUDATE(J)=0
        ICOUNT(1,J)=0
        ICOUNT(2,J)=0
        ITIME(1,J)=0
        ITIME(2,J)=0
800      CONTINUE
        IUDATE=0
        I=1
        JSHIP=0
        CSHIP(I)=CSHIP(NCASRP+1)
        CBDATE(I)=CBDATE(NCASRP+1)
        FLT(I)=FLT(NCASRP+1)
        CEDATE(I)=CEDATE(NCASRP+1)
        TDOWN(I)=TDOWN(NCASRP+1)
        SDOWN(I)=SDOWN(NCASRP+1)
        MDOWN(I)=MDOWN(NCASRP+1)
        CENSOR(I)=CENSOR(NCASRP+1)
        REP(I)=REP(NCASRP+1)
        CEIC(I)=CEIC(NCASRP+1)
        GO TO 250
1000      CONTINUE
1100      CONTINUE
        STOP
        END
/*
//GO.FT01F001 DD DISP=SHR,
//  DSN=MSS.S2908.SUBSET.UNIFIED2
//GO.FT02F001 DD DISP=(OLD,KEEP),
//  DSN=MSS.S2908.SUBSET.CASREPT

```

2. TRAINED UNITS ONLY IN CONTROL GROUP

This program is used to examine the OMT effect by comparing failure rates for units which receive training. Equipment time and failure counters in this program record only ships of interest which participated in the training program.

```

//T365T  JOB (2908,9999),'EIC FORTRAN',CLASS=G
//  EXEC FORTVCLG,REGION.GO=1500K
//FORT.SYSIN DD *
  PARAMETER (NEIC=111,NSHIP=700,NCS=900,NCL=22)
  CHARACTER*1  B2,REP(NCS)
  CHARACTER*2  B1
  CHARACTER*4  EICTBL(NEIC),CEIC(NCS)
  CHARACTER*5  A1
  CHARACTER*6  D1,E1

```

```

CHARACTER*8 UCNAME(1351),C2,CRSTBL(NEIC),SHIP(NSHIP),USHIP(1351),
.CSHIP(500),CLASS(NCL+1)
CHARACTER*10 C1
INTEGER UDATE(1351),CBDATE(NCS),
.FLT(NCS),CEDATE(NCS),TDOWN(NCS),SDOWN(NCS),MDOWN(NCS),CENSOR(NCS)
INTEGER ICOUNT(2,NEIC),ITIME(2,NEIC),ITRAIN
(NEIC),LUDATE(NEIC),ITOTAL(2,NEIC),ITOTTM(2,NEIC)
DATA EICTBL/'TF01','TF03','TF04','CC01','CC03','EB03','KF01',
.'KF03','TLOF','TLOG','TLOH','TLOJ','LBOM','LBON','LBOP','LB00',
.'K703','K705','F703','F705','4708','4704','4703','F301','F303',
.'F308','F309','F30A','F30C','F30D','F30E','F30G','F30H','FB01',
.'FB05','FB06','FB07','E901','E905','E907','E909','K301','K303',
.'K308','K309','K30A','K30C','K30D','K30E','K30G','K30H','KA01',
.'KA05','KA06','KA07','T707','T708','T401','T403','T404','T405',
.'T406','T407','T408','T409','T40S','T40T','T501','T504','N401',
.'N403','N404','N405','N406','N407','N408','N409','N40A','N40B',
.'N40C','N40D','N40E','N40F','N40G','N40H','N40J','N40K','N40L',
.'N40M','N40N','N40P','N40Q','N40R','N40S','N40T','N40U','N40V',
.'N40W','N40X','T901','T903','T904','T405','T906','T907','T908',
.'T909','T911','T90A','T90C',/
DATA CRSTBL/ 2*'AIR COMP',1*'DRY AIR',9*'ELEC MOT',4*'MK 19',
. 4*'STEAMVAL',1*'60/400HZ',2*'60/400MG',34*'CENTPUMP',
.12*'AC&R',30*'DE',11*'FIRE',/
DATA CLASS/'AD','AE','AO','AOR','AR',
.'CG','CGN','CV','DD','DD 0963',
.'DDG','DDG 0993','FF','FF 1052','FFG',
.'FFG 0007','LCC','LHA','LPD','LPH',
.'LSD','LST','ZZZZZZZZ',/

```

```

C
2 FORMAT(A2,A8,A1,A8,A8,I5)
4 FORMAT(A5,A8,A10,I5,I1,A6,I5,I4,I4,I4,I1,A6,A1,A4)
6 FORMAT(1X,'JSHIP',1X,'SHIP','NCASRP')
7 FORMAT(1X,I4,2X,A8,2X,I4,2(2X,I5))
8 FORMAT(1X,A8,2(1X,I5,1X,I7,1X,F8.6),1X,A4,1X,A8)
9 FORMAT(2X,A8,2X,I4,4X,I4,2X,F12.6,2X,4X,I4,2X,I4,2X,F12.6,1X,A4,
.2X,I5)
10 FORMAT(2X,A8,2X,A8,2X,I5)
11 FORMAT(2X,A8,2X,I3,2X,A4,2X,A8,6(2X,I5))
C
READ UNIFIED DATA
JSHIP=0
LSHIP=0
DO 100 I=1,1351
READ(1,2,END=110)B1,USHIP(I),B2,UCNAME(I),C2,UDATE(I)
C
TEST FOR NEW SHIP
DO 15 J=1,NSHIP
IF(SHIP(J).EQ.USHIP(I))THEN
JJ=J
GO TO 20
ENDIF
15 CONTINUE
C
NEW SHIP
JSHIP=JSHIP+1
IF (JSHIP.GT.NSHIP)STOP 'JSHIP.GT.NSHIP'
JJ=JSHIP
SHIP(JSHIP)=USHIP(I)
20 CONTINUE
100 CONTINUE
110 CONTINUE
C
READ CASREP FILE AND PROCESS DATA FOR ONE SHIP AT A TIME
NCLASS=1
DO 150 J=1,NEIC
ITRAIN(J)=1
LUDATE(J)=0
ICOUNT(1,J)=0
ICOUNT(2,J)=0
ITIME(1,J)=0
ITIME(2,J)=0
ITOTAL(1,J)=0
ITOTAL(2,J)=0
ITOTTM(1,J)=0

```

```

ITOTTM(2,J)=0
150 CONTINUE
IUDATE=0
JSHIP=0
I=0
DO 1000 K=1,90000
200 CONTINUE
I=I+1
READ(2,4 END=280)A1,CSHIP(I),C1,CBDATE(I),FLT(I),D1,CEDATE(I)
,TDOWN(I),SDOWN(I),MDOWN(I),CENSOR(I),E1,REP(I),CEIC(I)
250 CONTINUE
IF(I.EQ.1) THEN
C2=CSHIP(I)
ELSE
IF(CSHIP(I).NE.C2) GO TO 300
ENDIF
GO TO 200
280 CONTINUE
LSHIP=1
300 CONTINUE
NCASRP=I-1
IF (NCASRP.GT.NCS) STOP 'NCASRP.GT.NCS'
DO 500 J=1,NSHIP
IF(C2.EQ.SHIP(J)) THEN
JSHIP=J
GO TO 510
ENDIF
500 CONTINUE
510 CONTINUE
DO 740 N=1,NCASRP
IUDATE=0
MTBF=0
JEIC=NEIC
JDUM=0
IF (N.EQ.1) GO TO 590
DO 580 NN=1,N-1
IF (CEIC(NN).EQ.CEIC(N)) THEN
MTBF=CBDATE(N)-CEDATE(NN)
END IF
580 CONTINUE
590 CONTINUE
DO 600 J=1,NEIC-1
IF(CEIC(N).EQ.EICTBL(J)) THEN
JEIC=J
GO TO 610
ENDIF
600 CONTINUE
610 CONTINUE
IF(N.EQ.1.OR.LUDATE(JEIC).EQ.0)GOTO 700
IF((CBDATE(N)-LUDATE(JEIC)).GT.365)THEN
ITRAIN(JEIC)=1
ENDIF
700 CONTINUE
C SKIP SHIPS WITH NO TRAINING
IF(JSHIP.EQ.0)GOTO 730
DO 720 I=1,1351
IF (C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.(CBDATE(N)-
UDATE(I)).GE.0.AND.(CBDATE(N)-UDATE(I)).LE.365) THEN
IUDATE=UDATE(I)
ITRAIN(JEIC)=2
LUDATE(JEIC)=IUDATE
JDUM=1
GO TO 730
ENDIF
720 CONTINUE
730 CONTINUE
C INCREMENT COUNTER
ICOUNT(ITRAIN(JEIC),JEIC)=ICOUNT(ITRAIN(JEIC),JEIC)+1
740 CONTINUE
C END OF CASREPS

```

```

C      TIME INCREMENT
      DO 770 JEIC=1,NEIC
      LUPDATE(JEIC)=0
      ITRAIN(JEIC)=1
      DO 750 I=1,1351
      IF(UPDATE(I).GT.4840)GO TO 750
      IF(C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.UPDATE(I).GT.
      .LUPDATE(JEIC))THEN
      IF((UPDATE(I)-LUPDATE(JEIC)).LT.365)THEN
      ITIME(2,JEIC)=ITIME(2,JEIC)+UPDATE(I)-LUPDATE(JEIC)
      ELSE
      ITIME(2,JEIC)=ITIME(2,JEIC)+365
      ENDIF
      LUPDATE(JEIC)=UPDATE(I)
      ITRAIN(JEIC)=2
      ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-UPDATE(I)))
      ENDIF
750  CONTINUE
760  CONTINUE
      IF(ITRAIN(JEIC).EQ.2.AND.(4840-LUPDATE(JEIC)).LT.365)THEN
      ITIME(2,JEIC)=ITIME(2,JEIC)+4840-LUPDATE(JEIC)-365
      ENDIF
      ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-CBDATE(1)))-ITIME(2,JEIC)
770  CONTINUE
      DO 780 J=1,NEIC
      IF(ITIME(1,J).GT.0) THEN
      FAIL1=FLOAT(ICOUNT(1,J))/FLOAT(ITIME(1,J))
      ELSE
      FAIL1=0.
      ENDIF
      IF(ITIME(2,J).GT.0) THEN
      FAIL2=FLOAT(ICOUNT(2,J))/FLOAT(ITIME(2,J))
      ELSE
      FAIL2=0.
      ENDIF
      IF(ITIME(2,J).EQ.0)GO TO 780
      ITOTAL(1,J)=ITOTAL(1,J)+ICOUNT(1,J)
      ITOTAL(2,J)=ITOTAL(2,J)+ICOUNT(2,J)
      ITOTTM(1,J)=ITOTTM(1,J)+ITIME(1,J)
      ITOTTM(2,J)=ITOTTM(2,J)+ITIME(2,J)
780  CONTINUE
790  CONTINUE
      END CLASS
C      IF(LSHIP.EQ.1.OR.LGE(CSHIP(NCASRP+1),CLASS(NCLASS+1)))THEN
      DO 795 J=1,NEIC
      IF(ITOTTM(1,J).GT.0)THEN
      FAIL1=FLOAT(ITOTAL(1,J))/FLOAT(ITOTTM(1,J))
      ELSE
      FAIL1=0.
      ENDIF
      IF(ITOTTM(2,J).GT.0)THEN
      FAIL2=FLOAT(ITOTAL(2,J))/FLOAT(ITOTTM(2,J))
      ELSE
      FAIL2=0.
      ENDIF
      IF((ITOTAL(1,J)+ITOTAL(2,J)+ITOTTM(2,J)).GT.0)
      .  WRITE(6,8)CLASS(NCLASS),ITOTAL(1,J),ITOTTM(1,J),FAIL1,ITOTAL(2
      .  J),ITOTTM(2,J),FAIL2,EICTBL(J),CRSTBL(J)
C      NEW CLASS
      ITOTAL(1,J)=0
      ITOTAL(2,J)=0
      ITOTTM(1,J)=0
      ITOTTM(2,J)=0
795  CONTINUE
      IF(LSHIP.EQ.1)GOTO 1100
      NCLASS=NCLASS+1
      IF(NCLASS.GT.NCL)STOP 'NCLASS.GT.NCL'
      ENDIF
C      START NEW SHIP
      DO 800 J=1,NEIC

```

```

      ITRAIN(J)=1
      LUDATE(J)=0
      ICOUNT(1,J)=0
      ICOUNT(2,J)=0
      ITIME(1,J)=0
      ITIME(2,J)=0
800  CONTINUE
      IUDATE=0
      I=1
      JSHIP=0
      CSHIP(I)=CSHIP(NCASRP+1)
      CBDATE(I)=CBDATE(NCASRP+1)
      FLT(I)=FLT(NCASRP+1)
      CEDATE(I)=CEDATE(NCASRP+1)
      TDOWN(I)=TDOWN(NCASRP+1)
      SDOWN(I)=SDOWN(NCASRP+1)
      MDOWN(I)=MDOWN(NCASRP+1)
      CENSOR(I)=CENSOR(NCASRP+1)
      REP(I)=REP(NCASRP+1)
      CEIC(I)=CEIC(NCASRP+1)
      GO TO 250
1000 CONTINUE
1100 CONTINUE
      STOP
      END

/*
//GO.FT01F001 DD DISP=SHR,
//  DSN=MSS.S2908.SUBSET.UNIFIED2
//GO.FT02F001 DD DISP=(OLD,KEEP),
//  DSN=MSS.S2908.SUBSET.CASREPT
//GO.FT03FC01 DD DISP=(OLD,KEEP),SPACE=(19032,(304,10)),
//  DCB=(RECFM=FB,LRECL=78,BLKSIZE=19032),
//  UNIT=SYSDA,
//  DSN=MSS.S2908.FAILRATE

```

3. EXAMPLE OF SUMMED FAILURE RATE FILE

The following is an example of the output of the failure rate program. The relationship between EICs and OMT courses exist in the last two columns.

DD	0963	169	35018	0.004826	33	12219	0.002701	TF01	AIR COMP
DD	0963	106	35018	0.003027	23	12219	0.001882	TF03	AIR COMP
DD	0963	18	30467	0.000591	10	16549	0.000604	TF04	DRY AIR
DD	0963	0	29036	0.000000	0	19860	0.000000	CC01	ELEC MOT
DD	0963	0	29036	0.000000	1	19860	0.000050	CC03	ELEC MOT
DD	0963	0	29036	0.000000	1	19860	0.000050	EB03	ELEC MOT
DD	0963	0	29036	0.000000	0	19860	0.000000	KF01	ELEC MOT
DD	0963	0	29036	0.000000	0	19860	0.000000	KF03	ELEC MOT
DD	0963	0	29036	0.000000	0	19860	0.000000	TLOF	ELEC MOT
DD	0963	0	29036	0.000000	0	19860	0.000000	TLOG	ELEC MOT
DD	0963	0	29036	0.000000	0	19860	0.000000	TLOH	ELEC MOT
DD	0963	0	29036	0.000000	0	19860	0.000000	TLOJ	ELEC MOT
DD	0963	3	47016	0.000064	0	0	0.000000	LB0M	MK 19
DD	0963	2	47016	0.000043	0	0	0.000000	LB0Q	MK 19
DD	0963	0	34231	0.000000	0	13866	0.000000	K703	STEAMVAL
DD	0963	0	34231	0.000000	0	13866	0.000000	K705	STEAMVAL
DD	0963	0	34231	0.000000	0	13866	0.000000	F703	STEAMVAL
DD	0963	0	34231	0.000000	0	13866	0.000000	F705	STEAMVAL
DD	0963	33	35481	0.000930	11	12045	0.000913	4708	60/400HZ
DD	0963	11	47016	0.000234	0	0	0.000000	4703	60/400MG
DD	0963	1	35417	0.000028	0	12669	0.000000	F301	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F303	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F308	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F309	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F30A	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F30C	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F30D	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F30E	CENTPUMP

DD	0963	0	35417	0.000000	0	12669	0.000000	F30G	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	F30H	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	FB01	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	FB05	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	FB06	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	FB07	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	E901	CENTPUMP
DD	0963	0	35417	0.000000	1	12669	0.000079	E905	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	E907	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	E909	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K301	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K303	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K308	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K309	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K30A	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K30C	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K30D	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K30E	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K30G	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	K30H	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	KA01	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	KA05	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	KA06	CENTPUMP
DD	0963	0	35417	0.000000	0	12669	0.000000	KA07	CENTPUMP
DD	0963	6	35417	0.000169	3	12669	0.000237	T707	CENTPUMP
DD	0963	8	35417	0.000226	0	12669	0.000000	T708	CENTPUMP
DD	0963	0	31782	0.000000	0	16135	0.000000	T401	AC&R
DD	0963	1	31782	0.000031	1	16135	0.000062	T403	AC&R
DD	0963	1	31782	0.000031	1	16135	0.000062	T404	AC&R
DD	0963	29	31782	0.000912	3	16135	0.000186	T405	AC&R
DD	0963	1	31782	0.000031	0	16135	0.000000	T406	AC&R
DD	0963	0	31782	0.000000	0	16135	0.000000	T407	AC&R
DD	0963	9	31782	0.000283	1	16135	0.000062	T408	AC&R
DD	0963	0	31782	0.000000	2	16135	0.000124	T409	AC&R
DD	0963	19	31782	0.000598	11	16135	0.000682	T40S	AC&R
DD	0963	0	31782	0.000000	0	16135	0.000000	T40T	AC&R
DD	0963	0	31782	0.000000	2	16135	0.000124	T501	AC&R
DD	0963	3	31782	0.000094	1	16135	0.000062	T504	AC&R
DD	0963	1	47016	0.000021	0	0	0.000000	N401	DE
DD	0963	2	47016	0.000043	0	0	0.000000	N405	DE
DD	0963	1	47016	0.000021	0	0	0.000000	N406	DE
DD	0963	1	47016	0.000021	0	0	0.000000	N40R	DE
DD	0963	3	47016	0.000064	0	0	0.000000	N40S	DE
DD	0963	3	47016	0.000064	0	0	0.000000	N40T	DE
DD	0963	5	47016	0.000106	0	0	0.000000	N40U	DE
DD	0963	2	41320	0.000048	0	5696	0.000000	T901	FIRE
DD	0963	16	41320	0.000387	0	5696	0.000000	T903	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T904	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T405	FIRE
DD	0963	3	41320	0.000073	0	5696	0.000000	T906	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T907	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T908	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T909	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T911	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T90A	FIRE
DD	0963	0	41320	0.000000	0	5696	0.000000	T90C	FIRE

APPENDIX F

SPSSX AND SAS PROGRAMS USED IN ANALYSIS OF FAILURE RATES

1. SPSSX PROGRAM

The following program produces aggregate failure rates, sample size, F statistic, and degrees of freedom.

```
TITLE UNIFIED TRAINING CLASS TEST
FILE HANDLE THESIS/ NAME = 'THESIS DATA A1'
DATA LIST FILE = THESIS/ CLASS 2-9(A) NTCASRP 11-15 NTTIME 17-23 NTFAIL
      25-32 TCASRP 34-38 TTIME 40-46 TFAIL 48-55 EIC 57-60(A)
      COURSE 62-69(A)
SELECT IF (NTCASRP GT 0 OR TCASRP GT 0)
AGGREGATE      OUTFILE = *
      / BREAK = CLASS
      / NTREP NTTIM TREP TTIM = SUM(NTCASRP NTTIME TCASRP TTIME)
COMPUTE F=((2*NTTIM)*(2*(1+TREP)))/((2*(1+NTREP))*(2*TTIM))
COMPUTE N1=2*(1+NTREP)
COMPUTE N2=2*(1+TREP)
LIST
EXECUTE
FINISH
```

2. SAS PROGRAM

This SAS file uses the output of the SPSSx program above and computes a p-value from the F statistic and both degrees of freedom.

```
OPTIONS      LINESIZE=80;
DATA ONE;
  INPUT  COURSE $ 2-9 NTEP 12-18 NTTIM 20-27 TREP 31-36 TTIM 38-45
        F 51-54 N1 57-63 N2 66-72;
  PVALUE = 1 - PROBF(F,N1,N2);
  CARDS;
AD      144.00 298317.0      31.00 42194.00      1.56      290.00      64.00
AE      169.00 427438.0      46.00 141940.0      .83      340.00      94.00
AO      102.00 164604.0      29.00 36616.00      1.31      206.00      60.00
ACR     101.00 211353.0      28.00 61658.00      .97      204.00      58.00
AR      32.00 55956.00      22.00 29310.00      1.33      66.00      46.00
CG      563.00 765504.0     168.00 265391.0      .86     1128.00     338.00
CGN     242.00 298079.0      13.00 53422.00      .44      486.00      38.00
DD       90.00 214114.0       7.00 14668.00      1.28      182.00      16.00
DD 0963 457.00 1215882     105.00 305731.0      .92      916.00     212.00
DDG     1292.00 2019980     336.00 591734.0      .89     2586.00     674.00
DDG 0993 78.00 99367.00      26.00 12629.00      2.69      158.00      54.00
FF      309.00 426596.0     144.00 158296.0      1.26      620.00     290.00
FF 1052 1119.00 2573314     234.00 533898.0      1.01     2240.00     470.00
FFG     175.00 188311.0      25.00 31223.00      .89      352.00      52.00
FFG 0007 1168.00 457729.0     113.00 25970.00      1.72     2338.00     228.00
LCC      23.00 29404.00      16.00 11966.00      1.74      48.00      34.00
LHA     127.00 159570.0      29.00 10708.00      3.49      256.00      60.00
LPD     299.00 396566.0     175.00 224409.0      1.04      600.00     352.00
LPH     207.00 243029.0      85.00 115003.0      .87      416.00     172.00
LSD     191.00 455870.0      73.00 106840.0      1.64      384.00     148.00
LST     216.00 510697.0      56.00 128517.0      1.04      434.00     114.00
PROC PRINT DATA=ONE;
  VAR      COURSE PVALUE F N1 N2;
```


3. SAS OUTPUT

The following is an example of the output from the preceeding SAS program. This output was used to produce the tabular displays of results throughout this thesis.

SAS					
OBS	COURSE	PVALUE	F	N1	N2
1	AD	0.016842	1.56	290	64
2	AE	0.880972	0.83	340	94
3	AO	0.109704	1.31	206	60
4	AOR	0.572978	0.97	204	58
5	AR	0.154218	1.33	66	46
6	CG	0.960621	0.86	1128	338
7	CGN	0.999959	0.44	486	38
8	DD	0.294536	1.28	182	16
9	DD 0963	0.788806	0.92	916	212
10	DDG	0.973720	0.89	2586	674
11	DDG 0993	0.000030	2.69	158	54
12	FF	0.012228	1.26	620	290
13	FF 1052	0.451105	1.01	2240	470
14	FFG	0.730289	0.89	352	52
15	FFG 0007	0.000000	1.72	2338	228
16	LCC	0.046324	1.74	48	34
17	LHA	0.000000	3.49	256	60
18	LPD	0.343147	1.04	600	352
19	LPH	0.867186	0.87	416	172
20	LSD	0.000279	1.64	384	148
21	LST	0.407794	1.04	434	114

APPENDIX G FURTHER TABULAR RESULTS

1. TRAINED UNITS ONLY IN CONTROL GROUP

TABLE 7
FAILURE RATES BY CLASS (TRAINED UNITS, 2 YEAR TIME
HORIZON)

CLASS	$\lambda_1 - \lambda_2$	PVALUE
AD	.000606	.93
AE	.000298	.99
AO	.000167	.66
AOR	-.000192	.11
AR	.000569	.95
CG	.000088	.83
CGN	.000247	.74
DD	.000286	.69
DD 0963	-.000121	.02*
DDG	-.000029	.32
DDG 0993	.000149	.55
FF	-.000269	.04*
FF 1052	-.000075	.12
FFG	-.000702	.01*
FFG 0007	.000070	.53
LCC	-.000574	.22
LHA	-.001200	.04*
LPD	.000032	.62
LPH	.000125	.76
LSD	-.000060	.35
LST	.000121	.84

λ_1 - Failure Rate w/o OMT

λ_2 - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE 8
FAILURE RATES BY CLASS (TRAINED UNITS, 1 YEAR TIME
HORIZON)

CLASS	$\lambda_1 - \lambda_2$	PVALUE
AD	.000299	.69
AE	.000254	.98
AO	.000035	.48
AOR	-.000327	.02*
AR	.000630	.96
CG	.000082	.77
CGN	.000156	.60
DD	-.000517	.13
DD 0963	-.000198	.00*
DDG	-.000042	.27
DDG 0993	.000499	.63
FF	-.000310	.03*
FF 1052	-.000119	.05*
FFG	.000035	.42
FFG 0007	.000488	.67
LCC	-.001863	.01*
LHA	.000043	.47
LPD	-.000062	.29
LPH	-.000198	.12
LSD	-.000182	.13
LST	.000040	.60

λ_1 - Failure Rate w/o OMT

λ_2 - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE 9
FAILURE RATES BY EIC (TRAINED UNITS, 3 YEAR TIME
HORIZON)

EIC	$\lambda_1 - \lambda_2$	PVALUE
CC03	.000020	.68
EB03	.000016	.68
EB905	-.000079	.29
EB01	-.000222	.02*
EB305	.000102	.83
EB06	.000014	.67
EB07	.000199	.85
E30A	.000085	.79
E30D	.000479	.97
E30E	.000016	.53
E30G	-.000028	.48
E30H	.000093	.88
E301	.000037	.76
E303	.000081	.86
E308	.000009	.66
E309	.000097	.86
E703	-.000198	.14
E705	.000027	.68
K703	-.000068	.47
LBOM	.000178	.79
LBON	-.000084	.48
LBOP	.000336	.89
LB00	.000530	.97
N40C	.000037	.63
N40D	.000259	.77
N40L	-.000084	.36
N40P	-.000860	.19
N40Q	.000378	.32
N40R	-.000609	.29
N405	.000815	.91
TF01	.000601	.99
TF03	.000439	.98
TF04	-.000155	.40
T40S	-.000149	.26
T401	.000119	.96
T403	-.000079	.31
T404	.000127	.81
T405	.000212	.99
T406	-.000007	.56
T407	.001068	.97
T408	.000183	.93
T409	.000032	.72
T501	-.000039	.40
T504	-.000022	.48
T707	.000150	.99
T708	.000066	.79
T901	.000325	.99
T903	.000463	.99
T906	.000201	.86
4703	-.000061	.63
4704	-.001094	.19
4708	.000971	.97

* significant ($\alpha \leq .1$)

2. ALL SHIPS IN CONTROL GROUP

TABLE 10
FAILURE RATES BY CLASS (ALL UNITS, 2 YEAR TIME HORIZON)

CLASS	$\lambda_1 - \lambda_2$	PVALUE
AD	-.000131	.15
AE	.000081	.88
AO	-.000227	.08
AOR	-.000089	.18
AR	.000277	.91
CG	.000066	.84
CGN	.000371	.99
DD	-.000268	.07
DD 0963	-.000051	.11
DDG	.000033	.78
DDG 0993	-.001419	.00*
FF	-.000221	.00*
FF 1052	-.000006	.41
FFG	-.000034	.38
FFG 0007	-.001510	.00*
LCC	-.000730	.02*
LHA	-.002003	.00*
LPD	.000035	.66
LPH	-.000009	.44
LSD	-.000307	.00
LST	-.000006	.42

λ_1 - Failure Rate w/o OMT

λ_2 - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE II
FAILURE RATES BY CLASS (ALL UNITS, 1 YEAR TIME HORIZON)

CLASS	$\lambda_1 - \lambda_2$	PVALUE
AD	-.000190	.12
AE	-.000114	.90
AO	-.000256	.10
AOR	-.000217	.05*
AR	.000377	.95
CG	.000073	.80
CGN	.000350	.96
DD	-.000781	.00*
DD 0963	-.000124	.01*
DDG	.000019	.60
DDG 0993	-.001085	.01*
EE	-.000284	.00*
EE 1052	-.000039	.18
EEG	.000190	.70
EEG 0007	-.001137	.01*
LCC	-.001584	.00*
LHA	-.001215	.00*
LPD	-.000025	.38
LPH	-.000213	.04
LSD	-.000395	.00
LST	-.000040	.28

λ_1 - Failure Rate w/o OMT

λ_2 - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE 12
FAILURE RATES BY EIC (ALL UNITS, 3 YR HORIZON)

EIC	PVALUE	λ_1	λ_2	$\lambda_1 - \lambda_2$
CC03	.45	.000042	.000041	.000001
EE03	.24	.000012	.000025	-.000013
E905	.06	.000000	.000079	-.000079
FB01	.02*	.000262	.000403	-.000141
FB05	.20	.000065	.000093	-.000028
FB06	.29	.000063	.000083	-.000020
FB07	.63	.000033	.000000	.000033
F30A	.18	.000064	.000124	-.000060
F30D	.85	.000235	.000068	.000166
F30E	.37	.000077	.000083	-.000006
F30G	.50	.000318	.000031	.000287
F30H	.97	.000549	.000363	.000186
F30I	.26	.000273	.000312	-.000038
F30J	.62	.003636	.003543	.000093
F30K	.12	.000466	.000564	-.000099
F30L	.62	.000845	.000804	.000040
F703	.02*	.000755	.000963	-.000209
F705	.35	.000106	.000119	-.000013
K703	.24	.000000	.000068	-.000068
LB0M	.22	.000152	.000196	-.000044
LB0N	.00*	.000778	.001689	-.000911
LB0P	.89	.000258	.000116	.000143
LB0Q	.99	.000464	.000133	.000331
N40C	.55	.000129	.000071	.000058
N40D	.55	.001531	.001461	.000070
N40E	.38	.000023	.000000	.000023
N40L	.48	.000085	.000055	.000030
N40M	.51	.000049	.000000	.000049
N40N	.38	.000081	.000000	.000081
N40P	.11	.000761	.001281	-.000521
N40Q	.22	.000325	.000378	-.000052
N40R	.10	.000180	.000337	-.000157
N40S	.40	.000031	.000000	.000031
N40T	.73	.000136	.000000	.000136
N40V	.65	.000157	.000000	.000157
N401	.12	.000037	.000000	.000037
N405	.69	.000062	.000000	.000062
N408	.41	.000033	.000000	.000033
N409	.22	.000045	.000000	.000045
TF01	1.00	.002972	.002172	.000800
TF03	.99	.002873	.002422	.000451
TF04	.46	.000595	.000574	.000022
T40S	.18	.000500	.000601	-.000101
T401	.96	.000129	.000059	.000070
T403	.74	.000047	.000025	.000022
T404	.55	.001574	.001556	.000019
T405	.98	.000425	.000267	.000158
T406	.40	.000032	.000032	.000000
T407	.51	.000254	.000178	.000076

TABLE 12
FAILURE RATES BY EIC (ALL UNITS, 3 YR HORIZON) (CONT'D.)

T408	.90	.000287	.000202	.000085
T409	.66	.000051	.000031	.000020
T501	.05*	.000020	.000075	-.000055
T504	.09	.000131	.000190	-.000059
T707	.98	.000259	.000134	.000125
T708	.22	.000300	.000346	-.000046
T90C	.66	.000053	.000000	.000053
T901	.82	.000058	.000000	.000058
T903	.94	.000287	.000145	.000142
T904	.31	.000072	.000000	.000072
T906	.28	.000056	.000057	-.000001
T908	.46	.000043	.000000	.000043
T909	.22	.000039	.000000	.000039
4703	.01*	.001754	.002648	-.000895
4704	.00*	.000158	.000539	-.000381
4708	.09	.001499	.001852	-.000353

λ_1 - Failure Rate w/o OMT

λ_2 - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

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